MANAGING RISKS IN AGRICULTURAL SUPPLY CHAIN IN INDIA

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BY

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All errors and limitations remaining in this thesis are mine alone.

TRIBHUVAN NATH

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LIST OF ABBREVIATIONS

AIC	Agriculture Insurance Company
AICRP	All India Coordinated Research Project
ANOVA	Analysis of Variance
APEDA	Agricultural and Processed Food Products Export Development Authority
APMC	Agricultural Produce Market Committee
BRICS	Brazil, Russia, India and China
CACP	Commission for Agricultural Costs and Prices
CAGR	Compounded Annual Growth Rate
CBO	Community Based Organization
CCB	Central Cooperative Bank
CCIS	Comprehensive Crop Insurance Scheme
CRED	Centre for Research on the Epidemiology of Disasters
CSIR	Council of Scientific and Industrial Research
CSO	Central Statistics Organization
CV	Coefficient of Variation
DPAP	Drought Prone Area Programme
EPA	Environmental Protection Agency
ERR	Economic Rate of Return
ESFIM	Empowering Smallholder Farmers in Markets
F&V	Fruits and Vegetables
FAO	Food and Agriculture Organization
FAOSTAT	Food and Agriculture Organization Statistical Databases
FCI	Food Corporation of India
FDI	Foreign Direct Investment
FFS	Farmers Filed School
FICCI	Federation of Indian Chambers of Commerce and Industry
FMEA	Failure Modes and Effects Analysis
GAP	Good Agricultural Practices
GDP	Gross Domestic Product
GM	Genetically Modified
GOI	Government of India
GSI	Geological Survey of India

HAFED	Haryana State Co-operative Supply and Marketing Federation
HP	Himanchal Pradesh
HYV	High Yielding Variety
HYVA	High Yielding Variety Agriculture
HYVP	High Yielding Varieties Programme
IAAP	Intensive Agriculture Area Programme
IBEF	India Brand Equity Foundation
ICAR	Indian Council of Agricultural Research
ICMR	Indian Council of Medical Research
ICRIER	Indian Council for Research on International Economic Relations
ICT	Information and Communications Technology
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
IMD	Indian Meteorological Department
IPCC	Intergovernmental Panel on Climate Change
IPM	Integrated Pest Management
IRDP	Integrated Rural Development Programme
IVRI	Indian Veterinary Research Institute
J&K	Jammu and Kashmir
KCC	Kisan Credit Card
KVK	Krishi Vigyan Kendra
MFI	Microfinance in India
MGNREGA	Mahatma Gandhi National Rural Employment Guarantee Act
MNAIS	Modified National Agricultural Insurance Scheme
MNCs	Multinational Companies
MOA	Ministry of Agriculture
NABARD	National Bank for Agriculture and Rural Development
NAIS	National Agricultural Insurance Scheme
NASA	National Aeronautics Space Association
NATCOM	National Communication
NCDEX	National Commodity and Derivatives Exchange Limited
NCRB	National Crime Records Bureau
ND	National Demonstration
NE	North East

NGO	Non-government Organizations
NGO	Non-governmental Organizations
NPK	Nitrogen, Phosphorous, and Potash (Potassium)
NREGA	National Rural Employment Guarantee Act
NSSO	National Sample Survey Organization
OBC	Other Backward Caste
OECD	Organisation for Economic Co-operation and Development
OFDA	Office of US Foreign Disaster Assistance
PACS	Poorest Areas Civil Society
PAIS	Personal Accident Insurance Scheme
PDS	Public Distribution System
PMGSY	Pradhan Mantri Gram Sadak Yojana
R&D	Research and Development
RIDF	Rural Infrastructure Development Fund
RKBY	Rashtriya Krishi Bima Yojna
RMWG	Risk Management Working Group
RPN	Risk Priority Numbers
RTI	Right to Information
SD	Standard Deviation
SPSS	Statistical Package for the Social Sciences
TASS	Trust for Advancement of Agricultural Sciences
TE	Triennium Ending
TERI	The Energy and Resources Institute
UK	United Kingdom
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UP	Uttar Pradesh
USA	United States of America
USAID	United States Agency for International Development
UTs	Union Territories
WBCIS	Weather based Crop Insurance Scheme
WTO	World Trade Organization

Chapter 1

INTRODUCTION

This chapter presents the background and motivating interest of undertaking this research and emphasises the appropriateness of this dissertation in the emerging agribusiness system. It critically reviews the growth performance of Indian agriculture since independence and briefly discusses the twists and turns during various plan periods. Further, it describes the problem statement in terms of major risks and challenges being faced by Indian agriculture in its transition and structural change in the twenty-first century. In addition, this chapter describes the detailed objectives, research questions, and the structure of this dissertation.

1.1 Background

Historically, agriculture[1] has been the backbone of many economies including India. The post-independence period marks a turning point in the history of Indian agriculture, which is clear from the fact that compared with annual growth rate of less than 0.5 percent during pre-independence period (1904-05 to 1945-46) the agricultural sector recorded an annual growth rate of 2.8 per cent during 1950-51 to 2011-12 (CSO, 2012; Bhalla, 2008). Though its contribution to the overall Gross Domestic Product (GDP) of Indian economy has fallen from 55 percent in 1950-51 to less than 15 percent in 2011-12, a trend that is expected in the development process of any economy (as experiences from elsewhere in the world shows), the sector's importance in economic and social fabric goes well beyond this indicator. Still, this sector employs more than 50 percent of India's workforce and accounts for about 10 percent of export earnings (Sharma, 2011). It is critical source of livelihood of the vast majority of rural population particularly small-scale farmers, who constitute the majority of farming population i.e. more than 70% of the country population (Chand et al., 2011; World Development Report, 2008; Vyas, 2003). Agriculture is a dynamic in nature and evolved over the time and will continue to change in future as well (Saxowsky and Duncan, 2008).

[1]The term agriculture is derived from the latin words *ager* or *agri* meaning soils and *cultura* means cultivation. Agriculture is the art, science and business of crop production. It encompasses all aspects of crop production, livestock farming, fishery and forestry.

After the independence, the status of Indian agriculture has improved by leaps and bounds with advancements in production technologies as well as supportive policy measures. The high degree of targeted government interventions in the agricultural sector since the beginning of the first Five Year Plan (1950) and the late 1960s revolution so-called "Green Revolution" have transformed the country from a "begging bowl" image to "agricultural powerhouse". This has enabled a successful transition in Indian agriculture from its stagnation to a growth path. Now, the country is world's largest producer of milk, second largest producer of horticultural commodities (fruits & vegetables), third largest producer of food grains, fifth largest producer of eggs and ninth largest producer of poultry meat in the world, and is second only to China in terms of overall food production (Bhaskarachary, 2009; Singh, 2008; Birthal et al., 2005). The pivotal importance of agriculture[2] in the country was recognised for ensuring food & nutritional security to its population of more than 1 billion and also for alleviation of poverty in the country (Kumar and Nath, 2010).

Despite this domination, the agriculture sector, however, could not maintain its growth momentum in the 1990s after the initiation of economic reforms. The strategic growth in agriculture and the accelerated growth in industry reversed the structure of national GDP in Indian economy. The process of economic liberalization and privatization policies in the country has witnessed significantly higher economic growth at the start of 21stcentury but it failed to improve agricultural status (MSSRF, 2008). The country's overall GDP increased from 5.8 percent per annum during 1990-2000 to a peak 7.3 percent during 2001-2012. However, during the same period, agricultural GDP decelerated from on an average 3.2 percent to 2.9 percent per annum (Central Statistics Office-CSO, 2012). Declining performance of the sector in terms of its growth has been one of the major concerns facing policy makers and the scholars having interests in the sector. The slackened performance of agriculture may be attributed to decline in public investment in agriculture from 5 percent of agricultural GDP in 1980-81 to 3 percent in 2006-07 (TASS & IFPRI, 2009). Agricultural growth has always been a crucial component for inclusiveness; however, high GDP growth without high agricultural growth is likely to lead to acceleration in inflation, which would adversely affect the larger growth process in the country (GoI, 2011).

[2]The experience from BRICS countries indicates that a one percentage growth in agriculture is at least two to three times more effective in reducing poverty than the same growth emanating from non-agriculture sectors.

Slow agricultural growth is a matter of great concern as majority of India's rural population is directly/ indirectly dependent on agriculture for earning their livelihood. Performance of Indian agriculture also decelerated in terms of growth rate of crop yields as well as total agricultural output during the 1990s (Sharma, 2011). In addition, the share of agricultural exports in total export value declined from about 18.5 percent in 1990-91 to about 10.5 percent in 2010-11, while share of agricultural imports to total national imports increased from 2.8 percent in 1990-91 to about 3.5 percent in 2010-11 (GoI, 2011; Sharma, 2011). The all round failure to achieve sustained growth in agriculture has resulted from the potential risk and challenges facing agriculture in the 21st century (Ghorbani and Jafari, 2009; Wenner, 2005). The agriculture sector which is characterised by high exposure to risk is becoming an ever riskier over the years. Recent researches has observed that there is rising intensity, complexity, frequency and duration of agricultural risks of all kinds – climatic (hail, drought, flood, landsides, frost, tornados, hurricanes, heat waves, and storm surges), biological (diseases and insect infestations), geological (earthquakes, and tsunamis), market (price variability), and man-made (financial crisis, collapse of legal institutions) – impacting adversely the agriculture as a whole (Viswanathan et al., 2012; Ali and Kapoor, 2009). Besides, farming community, particularly the smallholders, faces several challenges arising from a range of socio-economic, demographic, structural and institutional factors that adversely affect its sustainability and livelihood (Viswanathan et al., 2012; World Bank, 2007).

Over a period of time, Indian agriculture is undergoing a major transformation with a shift in production, consumption and trade from foodgrains towards high-value agricultural commodities[3] (IFPRI, 2011; Birthal and Joshi, 2006; Gulati et al., 2005). The relative importance of grains and staple foods are declining while that of high value agriculture such as fruits, vegetables, milk, meat and eggs are significantly increasing as a share in agricultural output (Chand and Raju, 2008; Gulati et al., 2007). As evident from the fact that, the share of high-value commodities/ products (fruits and vegetables, livestock products, fisheries) increased from 37.3 percent in TE 1983-84 to 47.4 percent

[3]As opposed to traditional commodities, high value agricultural products have relatively high unit values and a high income elasticity of demand. Typically, high value agricultural products may have higher value-to-weight ratios than high volume commodities. In addition, they are rather labour-intensive, require high food safety and quality specifications, and need to be integrated in a well-coordinated supply-chain (http://www.rfpp.ethz.ch). For example, a crop, fish, livestock or non-timber forest product that returns a higher gross margin per unit of available resources (land, labour, capital, human capacities) than other products within a given location and context, may be considered as high value items.

in TE 2007-08 (Sharma and Jain, 2011). The structural change was largely driven by rapidly changing demand for high value food due to rising incomes, urbanisation and lifestyle changes (Birthal and Joshi, 2006). Also, the share of high value commodities in agricultural trade has been increasing over the decades (Sharma and Jain, 2011). The growth of high value agriculture presents both opportunities and challenges to various stakeholders in agricultural system. On a brighter side, new opportunities are unfolding in the form of increasing demand for high-value commodities in the domestic and global markets, which is pointing out towards the potential prosperity that can be brought into the farm sector (IFAD, 2011).

The entry of corporate sector and MNCs in developing countries with innovative business strategies of market-driven technologies, contract farming, processing of agri-products, developing organized retailing and exploring markets for exports is providing a new dimension to the Indian agriculture. At the same time, the changes are posing serious challenges, particularly, to small scale farmers on how to involve them in the capitalizing markets and ensuring the share of benefits arising from the new opportunities (Swinnen, 2007). The main challenges towards the small farmers, in the process of moving towards high value agriculture are high cost of production, insufficient technical knowledge of cultivation & plant protection, declining productivity, inadequate access to financial & extension services, improper post-harvest practice & poor handling, inadequate infrastructure and lack of storage and cold chain facilities, low bargaining power, problems of aggregation & transport costs, increasing agri-waste, growing marketing inefficiencies & lack of market information, poor governance & non-supportive policy, environmental constraints including those arising out of climate change. In addition to these, as the most of high value agricultural products are comparatively perishable in nature, it requires greater coordination in the way the food is produced, processed, marketed and consumed (Deshingkar et al, 2003; Busch and Bain, 2004; Henson and Reardon, 2005; Swinnen and Maertens, 2007).

Given the potential risks and challenges, agricultural growth in the country must increasingly rely on sustained and improved productivity growth through continued technological and institutional innovations. The agricultural improvements must be seen in an integrated view of supply chain and appropriate interventions need to be made on its weakest links to strengthen the chain for bringing efficiency and effectiveness. In the recent years, a number of interventions have been initiated by the

public and private sectors for improving the value chain linkages effectively managing the potential agricultural risk to tackle the emerging challenges and have thereby given a ray of hope to the farming community and the agriculture sector to move on a high growth trajectory so as to sustain high GDP growth.

1.2 Agricultural Growth Performance and Structural Change

Agriculture is the lifeline of more than 70 percent of India's population who are directly/ indirectly dependent on agriculture for their livelihood (Census of India, 2011). Therefore, agricultural performance in the country is a determining factor in the quality of life of over 742.5 million people living in the rural areas. Pre-independence, agriculture was practiced on traditional lines, typically subsistence basis, where farmers raised most of their crops for their own consumption instead of for trade with negligible/ little use of improved seeds, chemical fertilisers, pesticides, and farm machineries. Farm fields were small and scattered and farms were largely dependent on the rainfall for the irrigation. After independence, India has adopted a policy of planned agricultural development at varying stages with targeted interventions, embracing a wide variety of institutional and technological interventions to make the country self sufficient in food production. From the late 1960s onwards, the green revolution helped the sector maintain steady growth for more than two decades which enabled the country not to be food secure at national level but also to become food exporter to the world (Kumar and Nath, 2010).

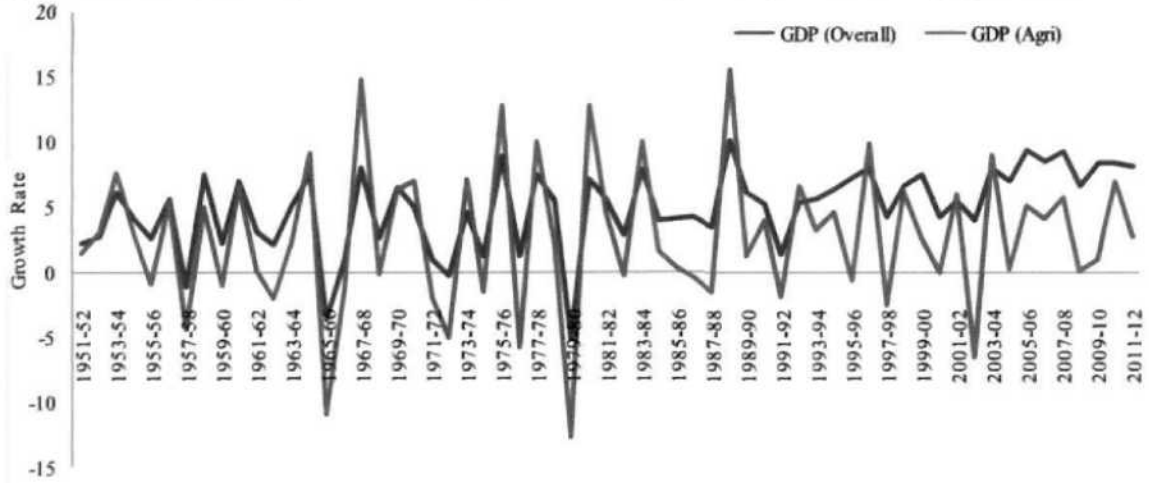
Today, with 195 million hectares area under cultivation (63% rainfed & 37% irrigated), India is the world's second largest producer of food next to China, and has the potential of being the biggest in the world (MoA, 2001b). The foodgrains production (defined in India as cereals plus pulses), which largely determines the status of food security[4] in the country, has touched a new peak of 241 million tonnes in 2010-11 from a mere 50.8 million tonnes in 1950-51; with an average growth rate of 3.2% per annum (Ministry of Agriculture GoI, 2012). Apart from food grains, the performance of high value crops and activities of allied agriculture – dairying, fishing, forestry – have shown significant growth in the recent decade. Known as fruit and vegetable basket of the world, India is the second largest producer of fruits and

[4]However, the availability of food grains is not a sufficient condition to ensure food security to the poor also necessary that the poor have sufficient means to purchase food (Prahadeeswaran et al., 2005).

vegetables accounting for about 16% of global vegetables production and 10% of world fruits production. The country is also a front runner in many fruits and vegetables with highest share in world production i.e. bananas (31%), papayas (42%), mangoes (42%), green peas (36%), cauliflower (30%). Much of the credit for this success should go to the several million of marginal and small farmers that form the backbone of Indian agriculture and the economy.

However, high performance variability has been observed in the growth of agriculture GDP as compared to the overall GDP of the country (Figure 1.2a). The variability is particularly pronounced due to the vagaries of weather and dominancy of subsistence nature of farming. The high degree of variability also stems from the problem of declining yields of few crops. However, as the figure shows, the agriculture growth rate in India's GDP had been growing earlier but in the last few years it is constantly declining.

Figure 1.2a: Comparative performance of growth of GDP (Overall) and GDP (Agri.) in India



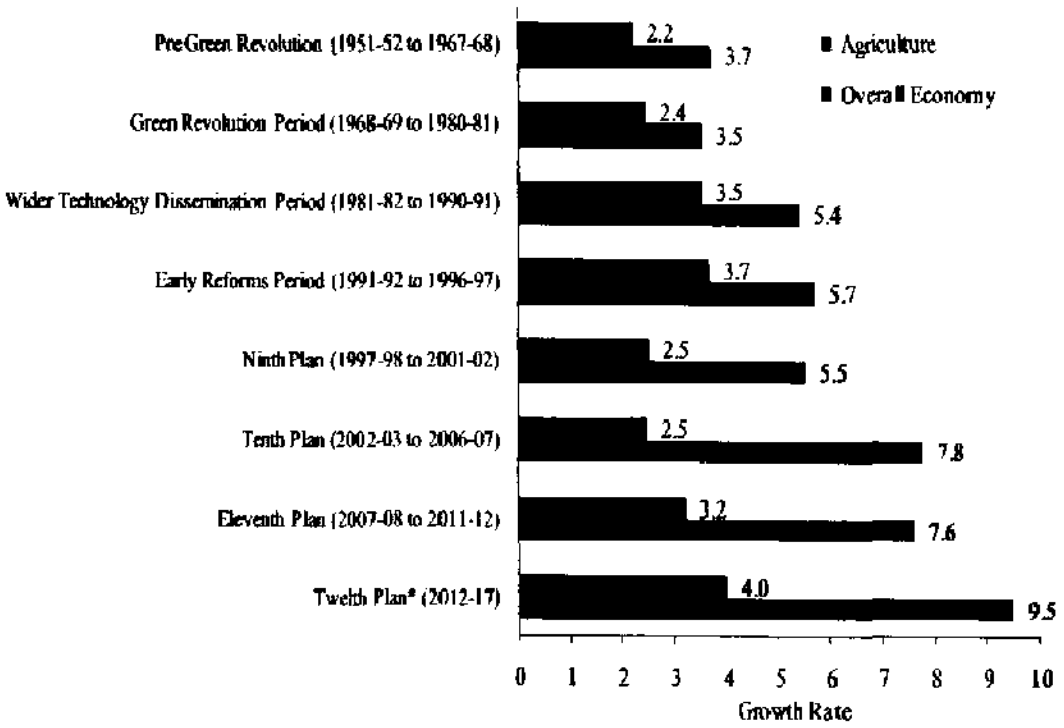
Source: Central Statistics Office (CSO)

Considering the high fluctuations in year-to-year growth in agricultural GDP, agriculture growth has been classified into seven phases (excluding twelve plan), for better understanding of growth phases in agriculture sector (Figure). As evident from the figure, the pre-green revolution period (1950-51 to 1967-68) observed an average agriculture GDP growth of 2.2 percent. The green revolution was kick-started during 1966-67 and the effects of adoption of modern technology and institutional reforms were started showing results after 1967-68 onwards. The green revolution period (1968-69 to 1980-81) marked a significant shift in technology transfer, adoption of higher yielding varieties and use of chemical fertilizers & pesticides including expanded

irrigated areas and improved access to institutional credit. It resulted as an improved growth rate of 2.4 percent during the green revolution. The subsequent period (1981-82 to 1990-91) is classified as the period of wider dissemination of technology maintained the growth momentum with superior growth rate at 3.5 percent. Several agricultural and rural development programmes such as IADP (Intensive Agriculture District Programme), IAAP (Intensive Agriculture Area Programme), ND (National Demonstration) and HYVP (High Yielding Varieties Programme) were launched to support the agriculture sector.

The early reform period (1991-92 to 1996-97) benefited largely from these initiatives and attained highest growth rate of 3.7 percent. Then, the deceleration of agricultural growth was started from ninth plan period onwards and a clear indication of slumping of the agricultural sector was visible till tenth plan. This slump is attributed as an outcome of substantial diversion of resources away from agriculture to other sectors of the economy. However, eleventh plan period (2007-08 to 2011-12) has recovered the growth to some extent and registered 3.2 percent growth rate. Nevertheless, it was far behind the targeted growth rate of 4 percent.

Figure 1.2b: Average overall and agriculture growth rate (%)



Source: Planning Commission, GoI *Targeted

Table 1.2 presents the growth dynamics of production of major crops/ crop groups during various phases. It is evident from table that the growth performance of the crop sub-sector was impressive in the first three phases of growth. This sector registered an annual growth rate of 2.15 per cent during the pre-green revolution period, which further improved to 2.64 per cent and 3.11 per cent in the phases of green revolution and wider dissemination respectively. In the initial years after the inception of planned development (First Five-Year Plan), agricultural policies primarily focused on expanding cultivated area, land reform, community development, and restructuring rural credit institutions. However, during Second and Third Five-Year Plans the priority on agriculture was diluted, and as a consequence, the sub-sector witnessed a deceleration during early sixties leading to food shortages and dependency on import of huge quantities of foodgrains for meeting domestic food demand. In the late 1960s, with "green revolution' interventions all the crops such as cereals, oilseeds, fruits and vegetables, and sugarcane grew at a rate of 2.0 to 3.9 percent per annum. Further, in the period of wider dissemination phase, cereals, sugarcane, oilseeds, and fruits and vegetables maintained its growth rate. Therefore, from the late 1960s onwards, the green revolution helped the sector to maintain steady growth for more than two decades till 1996-97. As observed from Table 1.2, the overall growth in crop sub-sector dipped to 1.51 per cent during post-reform period from 3.11 per cent during the period of wider dissemination. The deceleration was aided by a negative growth in cereals (-0.02 %), pulses (-0.09%) and sugarcane (-1.34%) and a poor performance of oilseeds (0.52%). However, the period of recovery (2006-07 to 2009-10) has helped most of these crops to recover their past.

Table 1.2: Trend Growth rates in VOP of various sub-sectors of crops at 1999-00 prices, 1950-50 to 2009-10 (Percent/annum)

Growth Phase	All Crops	Cereals	Pulses	Oilseeds	Fruits & Vegetables	Sugarcane
Pre-Green Revolution (1950-51 to 1967-68)	2.15	2.65	0.36	2.21	2.56	3.8
Green Revolution (1968-69 to 1985-86)	2.64	2.85	0.75	2.02	3.91	2.19
Period of Wider Dissemination (1986-87 to 1996-97)	3.11	3.06	0.99	6.56	3.69	4.21
Post-Reforms (1997-98 to 2005-06)	1.51	-0.0	-0.1	0.52	2.67	-1.3
Recovery (2006-07 to 2009-10)	1.97	2.24	1.68	0.91	4.11	-1.2

Source: Chand and Parappurathu (2011)

The agriculture sector also experienced transition and structural changes in agricultural input and output including food basket diversification since the Independence. As evident from the fact that, the share of chemical fertilizers in the total value of inputs increased gradually over the time, from less than 1 per cent in 1950–51 to 18.5 percent in 2007–08 (at constant 1999- 00 prices). At the same time, the share of organic manures declined from over 16 percent to just over 5 percent. Likewise, there is significant increase in the share of high value crops such as fruits and vegetables in total value of output from agriculture. The share of fruits and vegetables in the total value of agricultural output increased from 13.6 percent in TE 1993-94 to 16.9 percent TE 2007-08. Similarly, the share in total value of agricultural output for milk and meat also increased from 15.4 and 4.4 percent in TE 1993-94 to 17.4 and 4.5 percent in TE 2007-08 respectively (CSO, 2011). Also, the consumer food basket is getting diversified from traditionally cereals based items towards high-value foods such as fruits and vegetables, meat, milk etc. Rising incomes, increased urbanization and literacy, as well as improved infrastructure and closer ties to global trends fuelled by the information technology boom are driving increased consumer priority to high value food with greater concern on food quality and safety (FAO, 2003; Deininger and Sur, 2007).

1.3 Understanding Transition and Structural Shift towards High Value Agriculture

India is blessed with favourable climatic conditions for the production of a wide variety of crops. Cropping systems within country varies from regions to region due to different soil and climatic conditions across the regions and hence different agro-ecological setting. The Indian sub-continent has been divided into 20 agro-ecological zones which signify its diversified agricultural production from tropical and temperate crops. India has various types of soil ranging from the fertile alluvial of the Indo-Gangetic plains to the black and red soils of the Deccan Plateau. Indo-Gangetic Plain region comprising the states of Punjab, Haryana, plains of Uttar Pradesh, Bihar and plains of Jammu & Kashmir. The food systems in the Indo-Gangetic Plain are largely dependent on rice and wheat grown in rotation. Deccan Plateau covers parts of central and southern India. In the Deccan Plateau, genetic diversity is manifest in food crops like sorghum, millets, pigeonpea, chickpea, groundnut, sugarcane and mango. In the existing diverse agricultural landscapes, India has the potential to become 'food basket' of the world.

Realizing this, India paid considerable attention to the production of staple crops for food security, and to a few traditional export crops (coffee, cotton, cashew nuts and tea), as their means for economic growth and development. However, the progress was slow and patchy, largely due to traditional agricultural practices and research and development (R&D) and extension services were almost absent/ inadequately to gear the sector. There is significant shift towards high value agricultural production, consumption and trade pattern has been observed (CSO, 2011). The agriculture, which is the engine of growth and development, has been greatly influenced by the process of globalization, liberalization, mechanization, informationization, policy reform, urbanization and changing consumption behaviours has changed the structure of the Indian agriculture in the recent decades (Ali, 2007; Narayanmurthy, 2006; Kumar and Kumar, 2004; Murty, 2000; Rao, 2000). Globalization and trade liberalization bring in multinational companies (MNCs) into the local food retail sector through the establishment of "super-markets" with efficient supply chain management practices that emphasize high quality & safety standard with promotion of processed food. The economic reforms initiated in 90s however, did not include any specific package for agriculture rather it promoted for private investments (Dev, 2009).

The post-reform agricultural policies have largely promoted mechanization in the sector (Majumdar, 2006). Importantly, the advent of ICT has revolutionized the market information flows among the supply chain stakeholders including consumers (Arshad et al., 2006). Changing food consumption behaviors was observed as one of the major drivers of agricultural transformation (Timmer, 2007). Furthermore, increased urbanization has resulted in change in lifestyles and access to markets for various high value products both of which have increased the demand for fruits & vegetables, milk, eggs, meat, fish, and other high-value foods &processed foods (Reardon and Berdegue, 2002). The structural transformation can be considered as a defining characteristic of the development process (Syrquin, 2006).

1.3.1 Transition and Instability in Agricultural Production

Indian agriculture is passing through an era of transition from traditional to modern agriculture. The modernization is an agricultural transformation process of hybridization, mechanization, chemicalization, informationization and commercialization with profound changes in cropping pattern (Majumdar, 2006). The transformation process is characterized by application of high yielding seed varieties,

farm equipment& pump irrigation, use of chemical fertilizers, insecticides, pesticides, use of ICTs and agricultural credit (Mathur et al., 2006).

Traditionally, the agricultural food production in the country is largely dominated by foodgrains, which is comprised of wide range of crops like wheat, rice, coarse cereals and pulses. The last three decades have seen the total area under foodgrains declined by about 2.21 million hectares between TE 1992-93 and TE 2010-11 and this decline in area under foodgrains reduced the share of foodgrains in total cropped area from about 72 percent in TE 1993-93 to about 63 percent in TE 2010-11 (Table 1.3.1a). The decline in area under foodgrains resulted in increase in area under high value crops such as fruits and vegetables. Foodgrains production rose from 174.75 million tonnes in TE 1992-93 to 231.38 million tonnes in TE 2010-11, an increase by 20.06 million tonnes. Major gain in foodgrains production came mostly from rice and wheat crops. Fruit and vegetable production has increased more rapidly than that of foodgrains, largely due to increase in all sorts of area under crops and yield (Singh and Pal, 2010). However, during the same period, other important crops like pulses and coarse cereals experienced decline in their production mainly due to decrease in area. Yield was an important factor accounts for the growth in production of almost all the specified crops (except oilseeds) over the said period.

Table 1.3.1a: Trends in area, production and productivity of major crops/crop groups: (TE 1992/93 to TE 2010/11)

	Area (million ha)			Production (million tonne)			Productivity (tonne/ha)		
	TE 1992-93	TE 2002-03	TE 2010-11	TE 1992-93	TE 2002-03	TE 2010-11	TE 1992-93	TE 2002-03	TE 2010-11
Rice	42.37	43.60	41.45	73.94	83.38	89.57	1.75	1.91	2.16
Wheat	24.01	25.76	28.14	56.01	69.40	82.78	2.33	2.69	2.87
Cr. Cereals	34.72	28.92	25.40	31.76	30.18	34.01	0.91	1.04	1.34
Pulses	23.19	20.95	18.87	13.03	11.86	11.72	0.56	0.56	0.61
Foodgrains	124.29	119.23	122.08	174.75	194.81	231.38	1.41	1.63	1.85
Oilseeds	25.09	22.30	26.84	19.11	17.98	28.38	0.76	0.80	0.65
Sugarcane	3.70	4.42	4.31	241.03	293.52	306.58	65.10	66.51	65.33
Fruits	3.04	3.89	6.35	30.79	43.78	71.94	10.15	11.23	11.30
Vegetables	5.32	6.17	8.06	61.17	89.10	133.50	11.55	14.43	16.55

Source: Ministry of Agriculture, GoI TE: Triennium Ending

An instability analysis in area, production and yield of above crops was also carried out considering its direct/indirect affect on variability of farm income/income risk. Estimates of instability in area, production and productivity of foodgrains and non-foodgrain crops are presented in Table Table 1.3.1b. Coefficient of variation is a simple method for measuring instability. A high coefficient of variation implies high

instability. Instability was found lowest in area as compared to yield in almost all the crops except wheat and oilseeds. Variability in foodgrains production is substantially lower than the non-foodgrain crops. In the decade 2000s, the coefficients of variation (CVs) for production were estimated highest 19.8 percent for fruits, 19.7 percent for oilseeds, 17.4 percent for vegetables, and 13.5 percent for sugarcane.

Production instability in fruits and vegetables were almost triple than that in yield in 2000s. Several factors may be responsible for this instability in area, production and productivity of these crops, including the technology adoption, policy regime, natural hazards, seasonality and instability in national/ international food markets (Murshid et al., 2009). It was found that adoption of new technology had increased instability in foodgrains and agricultural production in India (Chand and Raju, 2008).A major reason for instability in food production is high fluctuation in food prices (UNEP). Natural calamities such as floods and droughts are common phenomena in the country, they adverse impact of natural calamities on foodgrain production (Hossain, 1990).

Table 1.3.1b: Instability in area, production and yield of major crops (Coeff. of variation, %)

	Area		**Production**		**Productivity**	
	90s	*2000s*	*90s*	*2000s*	*90s*	*2000s*
Rice	2.4	3.4	6.8	8.6	4.7	6.8
Wheat	5.5	4.1	11.2	7.2	6.3	3.7
Coarse cereals	6.9	4.2	9.3	12.5	9.6	12.9
Pulses	4.1	5.2	6.9	10.5	6.2	6.3
Foodgrains	1.5	2.4	6.9	8.3	6.9	6.4
Oilseeds	3.5	9.5	9.7	19.3	8.2	13.2
Sugarcane	6.9	10.4	9.6	13.5	4.1	4.5
Fruits	9.1	18.6	14.0	19.8	7.0	5.6
Vegetables	7.2	11.7	14.7	17.4	10.2	6.0

Source: Ministry of Agriculture, GoI

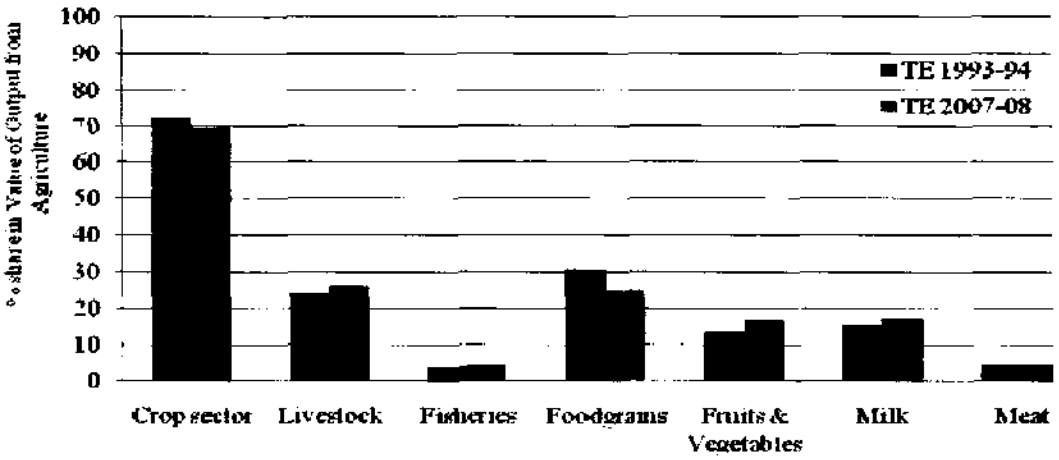
1.3.2 Structural Shift towards High Value Agriculture

Over the year, the high-value agriculture is becoming increasingly important, both as a share in agricultural output and in the food basket (Chand and Raju, 2008). In the post liberalization period, the agriculture sector in India observed a clear shift in production, consumption and trade from foodgrains to high-value agricultural commodities such as fruits and vegetables, milk and milk products, meat, fish, and processed food products (Gulati et al., 2005). Figure 1.3.2 clearly reflects the increased share of high value crops in total value of output from agriculture accelerated in the post reforms period. The

share of fruits and vegetables in the total value of agricultural output increased from 13.6 percent in TE 1993-94 to 16.9 percent TE 2007-08. This has happened largely due to increase in area and marginal improvements in yield (Sharma and Jain, 2011).

Likewise, the share in total value of agricultural output for milk and meat also increased from 15.4 & 4.4 percent in TE 1993-94 to respectively 17.4 & 4.5 percent in TE 2007-08. According to latest estimates published in Annual Reports of Department of Animal Husbandry, Dairying & Fisheries (GoI)[5], the value of output from livestock and fisheries sectors together at current prices was about 4,08,386 crore during 2009-10 (3,40,473 crore for livestock sector and 67,913 crore for fisheries) which is about 30% of the value of the output of 13,76,561 crore from total Agriculture & allied Sector. This increase is attributed to shifting production-mix to meet the growing demand for high value commodities.

Figure 1.3.2: Percentage share in value of output from agriculture sector



Source: CSO (2010)

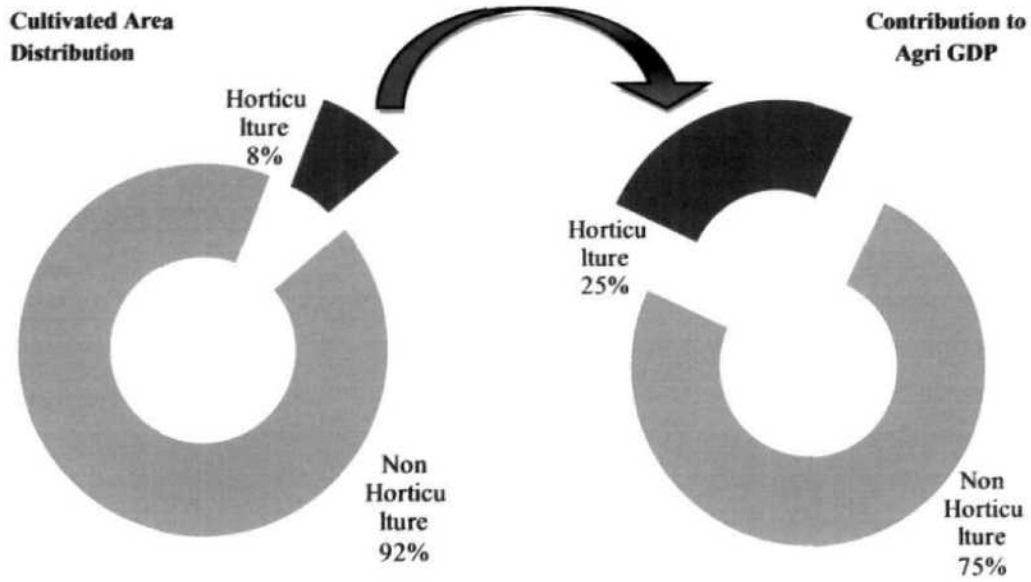
1.3.3 Horticulture: High Value Driver for Emerging Agriculture

Horticulture is fast emerging as a major commercial venture and value driver in emerging agricultural landscape in India. Fruits and vegetables significantly contribute and dominate Indian horticulture occupying 66 percent of the area under horticultural cultivation and contributing to more than 90 percent of the total horticultural production. Recent trends indicate that horticulture has contributed significantly to the growth in agricultural production (Table 5.2a). While the production of fruits and

[5]http://dahd.nic.in/dahd/WriteReadData/Annual%20Report%202010-11%20English.pdf

vegetables increased at a CAGR of 5.3 percent during the period 1996 to 2006, it was only 0.8 per cent for cereals (IVRI, 2011). The significance and importance of horticulture is evidenced by the fact that horticulture crops occupy only around 8 per cent of total cultivable area while contributing to around 25 per cent of agriculture GDP (Figure 1.3.3).

Figure 1.3.3: Contribution of horticulture to agriculture GDP (2005-06)



Source: IVRI (2011)

1.3.4 India: The Emerging Vegetable Basket of World

As a traditional giant country of vegetable production, India is the second largest producer of vegetables in the world after China and accounts for about 15% of the world's production of vegetables. Around 8 million hectares of area is under vegetable cultivation, which is about 5.4% of the total area under cultivation in the country. Vegetables farming enable the achievement of high value agricultural production in the country, organized on a relatively small area. The vegetable production is also extremely beneficial in the context of nutrition, employment, and income generation (USAID, 2011). The diverse agro-climatic zones in the country make it possible to grow almost all varieties of fresh vegetables in the country. The major vegetables grown in India are potato, tomato, onion, brinjal, cabbage and, cauliflower which account for around 60 percent of the total vegetable production in the country. India is the second largest producer of vegetables (ranks next to China) and accounts for about

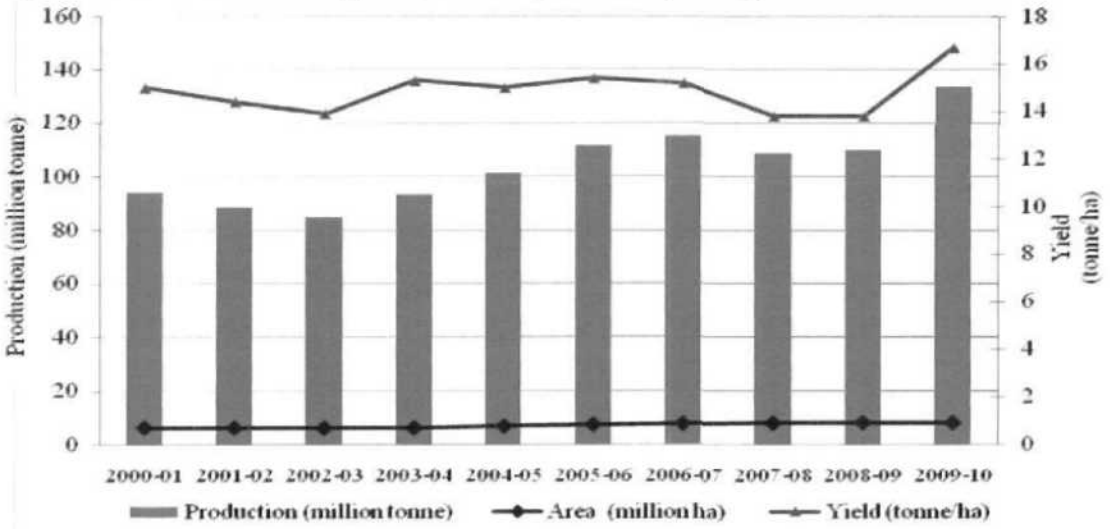
13.4% of the world's production of vegetables and also occupies first position in the production of cauliflower, followed by second in onion and third in cabbage in the world (Kundu, 2012). According to National Horticulture Board (GoI), the current production level is over 133 million tonnes and the total area under vegetable cultivation is around 8 million hectares, which is about 3% of the total area under cultivation in the country.

Figure 1.3.4a portrays the trends in area, production and productivity of vegetables over the years in the country. In the past decade 2000s, area under vegetable in the country has shown continuous increasing trend reflecting the growing interest of farmers in vegetable cultivation. Over the period of last 10 years, the total area under vegetable crops increased from 6.25 million hectares in 2000-01 to 7.99 million hectares in 2009-10. Remarkable increase in vegetable production from 93.9 million tonnes in 2000-01 to a peaked production of 133.7 million tonnes in 2009-10 was recorded. The increase in vegetables production has been attributed to substantial public support, geared at diversifying the sector. Farm level technical and financial assistant through the mission mode programmes and schemes like National Horticulture Mission, Integrated Horticulture Development (Gujarat and Tamil Nadu), and Subsidy on Horticulture Production Inputs to Small Farmers (Himachal Pradesh) have attracted farmers to venture into vegetable production as a business (Ali, 2008; Nath and Ahmad, 2011).

However, the production trends also shown a recent slowdown periods 2007-08 (108.7 million tonnes) and 2008-09 (110.1 million tonnes). Studies have pointed to a number of production constraints that slowdown the production trends. These constraints included pests, lack of trained labour, irrigation water shortage, market accessibility, lack of capital, transport, drought, flood, shortage of land and inaccessibility of inputs, poor farm management and lack of training (Seleka, 1999; Obopile, 2008; Madisa et al., 2010a). The contribution of yield improvement in the production increase was relatively high compared to the contribution of expansion in area[6]. In the said period, the yield observed fluctuating trends in the range of 13.8 – 16.7 tonnes/hectare. At the peak of yield (16.7 tonnes/hectares) in 2009-10, vegetable production also mounted at 133.7 million tonnes.

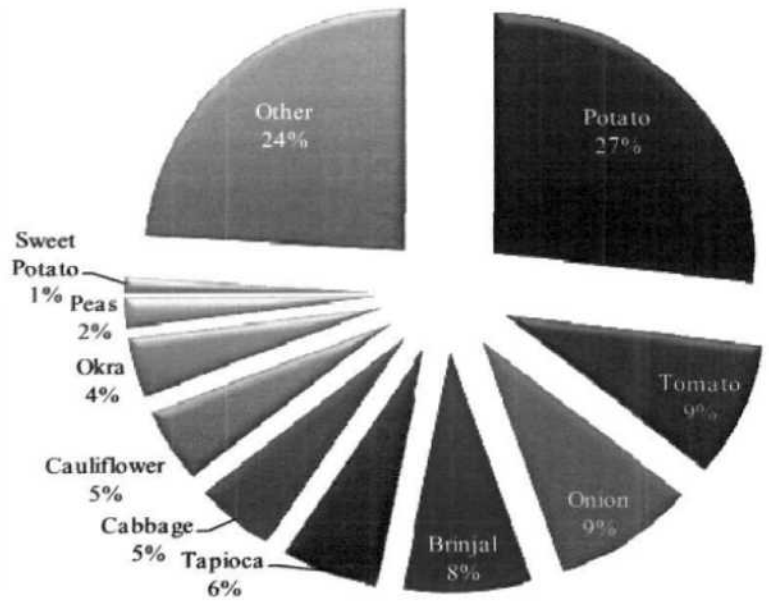
[6] http://parb.punjab.gov.pk/pdfs/Horticulture%20for%20the%20Poor.pdf

Figure 1.3.4a: Trends in area, production and productivity of vegetables in India



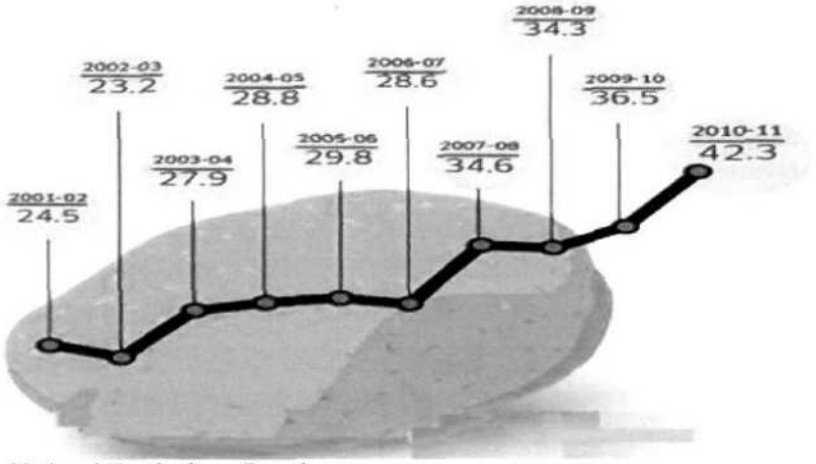
India is being blessed with the unique gift of nature of diverse climate and distinct seasons, make it possible to grow an array of vegetables number exceeding more than hundred types with highest share of potato (27%) followed by tomato (9%) and brinjal (9%) (Figure 1.3.4b). As evident from figure, potatoes are the leading vegetable crop in the country and its production trends determine the vegetable as well as horticulture trend in the country. In last one decade, there has been considerable increase in potato production from 24.5 million tonnes in 2001-02 to 42.3 million tonnes in 20010-11 (Figure 1.3.4c). Currently, Uttar Pradesh ranks first in the total production of vegetables in Indian states followed by West Bengal, Bihar, Orissa, Tamil Nadu and Karnataka.

Figure 1.3.4b: Production share of major vegetable crops in India (2009-10)



Source: IVRI (2011)

Figure 1.3.4c: Trends in potato production in India (in million tonnes)

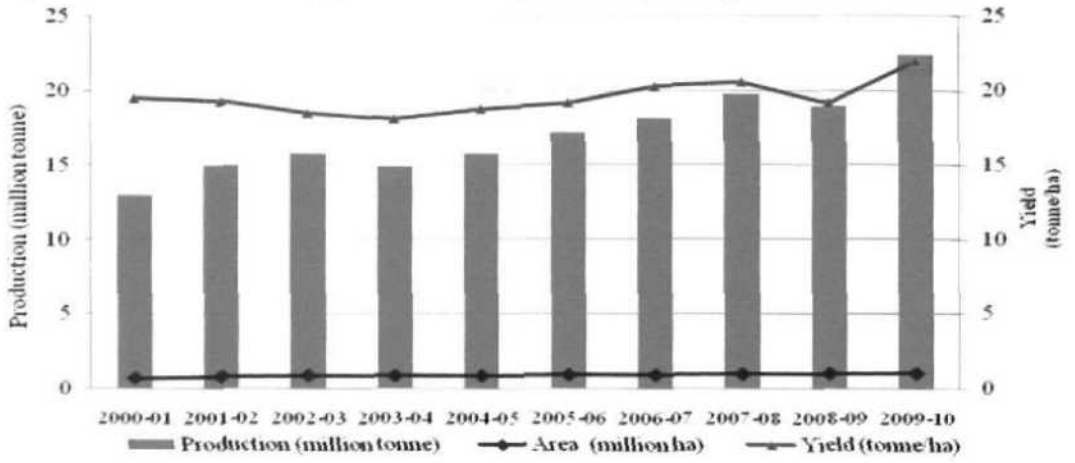


Source: National Horticulture Board

1.3.5 Uttar Pradesh: The Vegetable Basket of India

Uttar Pradesh is the largest producer of vegetables with 16 percent contribution to the national production from about 13 percent area under vegetable cultivation in the country. It occupies first amongst Indian states in the production of peas (50%) and potatoes (35%). The other important vegetables grown in the state are cauliflower, tomato, brinjal, onion, okra, cabbage and cucurbits. In 2009-10, vegetables were cultivated in an area of 1.02 million hectares and accounted for 22.4 million tonnes of peaked production. Figure 1.3.5 exhibits that from the year 2001 onwards area under vegetables has been increasing that resulted into the constant increase in vegetable production. However, a downward trend in the year 2009 was also observed. This may be due to the fact that 30 percent dip in potato production in the leading state West Bengal in 2009 than the previous year on account of late blight. Regarding trend in yield, it was observed that it ranged between 18.1 – 22.0 tonnes/hectare, in the said duration.

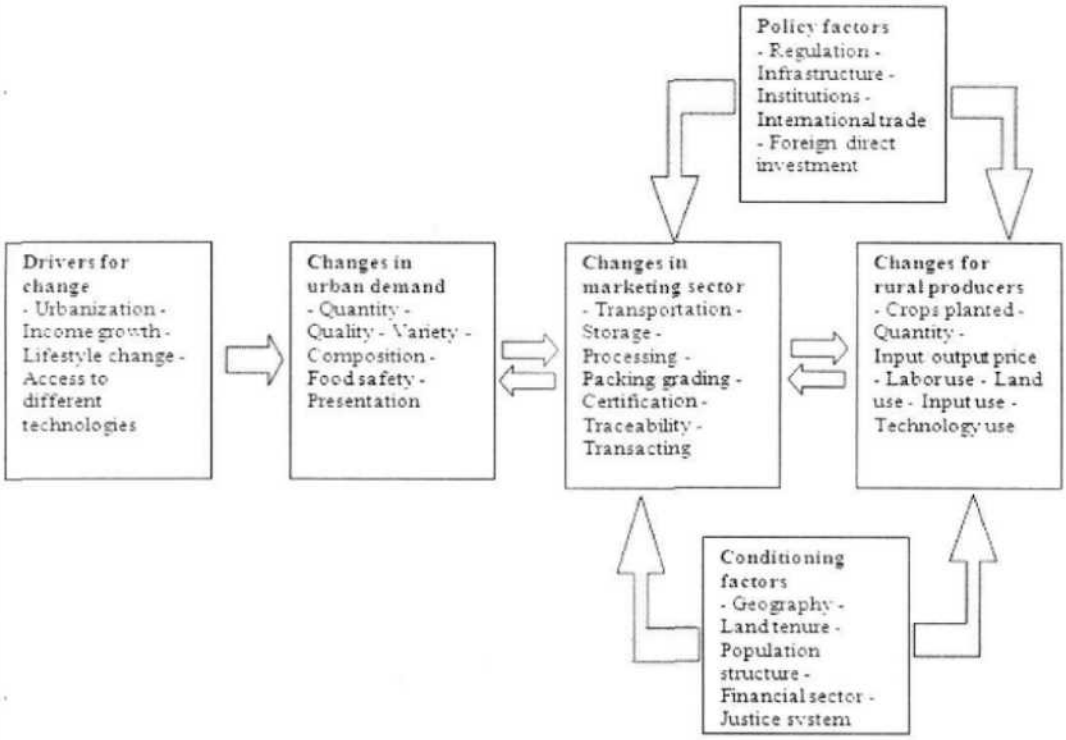
Figure 1.3.5: Trends in area, production and productivity of vegetables in Uttar Pradesh



1.4 Emerging High Value Supply Chain Structure

Above discussion confirms that agri-food supply chains in the country are changing significantly with structural changes in production, trade and consumption pattern towards high value food products. Also, there is growing importance of quality and safety standards including vertical coordination and emergence of large modern food retail chains. A framework for understanding the changes in agri- food supply chains is presented in Figure 1.4a.

Figure 1.4a: Changes in agri-food supply chains in India



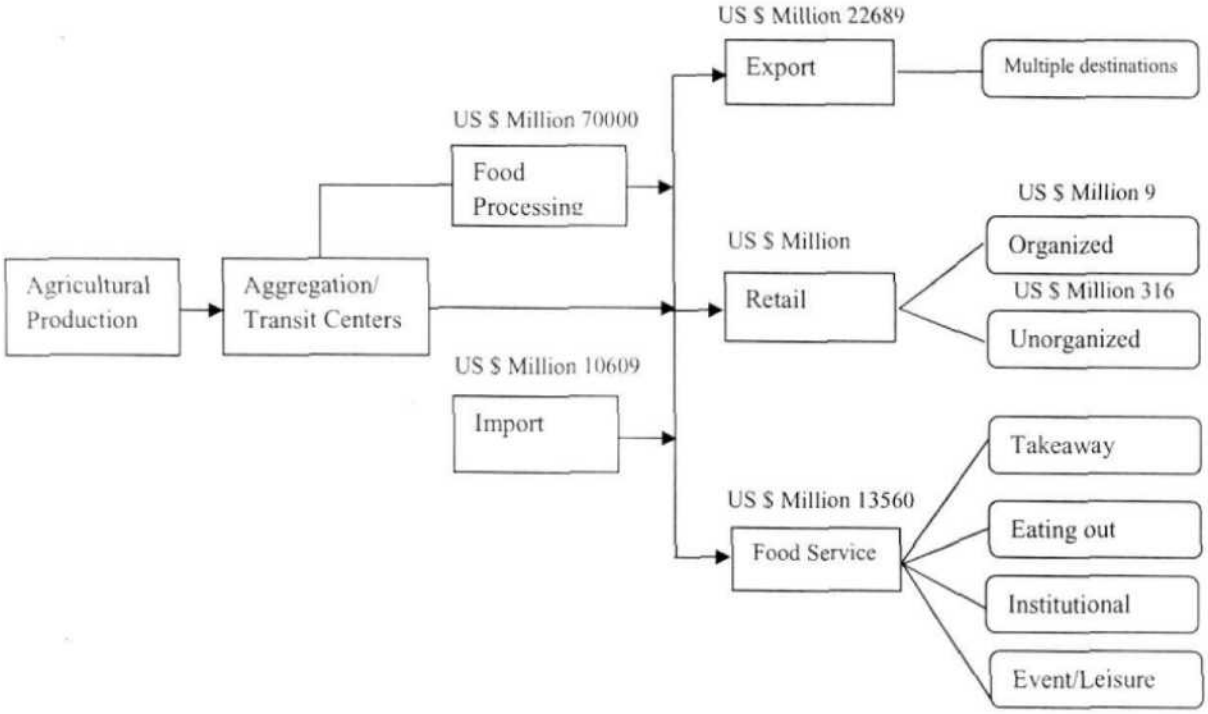
Source: Adopted from Minten et. al (2009)

With above changes, the country is experiencing emergence of high-value & high-standards food supply chains such as horticulture, meat and dairy products, destined for high-income markets also targeting export to big international market. The high value chains are becoming more organized and standards with a move from arm's-length market relations and spot-market transactions towards more explicit forms of co-ordination in the chains (Gereffi et al., 2005; Humphrey and Schmitz, 2001). In comparison to traditional commodities chains, the high value chains are considered to

be more efficient with increased backward and forward linkages[7]. As efficiency of a supply chain depends upon the extent to which both the backward as well as forward linkages are integrated along with the functions and stakeholders (Narula and Nainwal, 2010; Lambert and Cooper, 1998).

However, India is in the midst of these changes which can be understand in terms of the industrial structure which are typically dimensioned in terms of market size (Minot and Roy, 2007) (Figure 1.4b). Still, the high value supply chains such as vegetables are highly unorganized and inefficient spreaded across the distant country locations (see country vegetable map). As highlighted in the map, major eight vegetables producing states contribute to more than 70 percent of total flows of vegetables in the country. The major aggregation of vegetables is done at five metro locations – Mumbai, Delhi, Kolkata and Chennai including Banglore. Whereas eight country locations are major vegetable processing centers (Figure 1.4c).

Figure 1.4b: Current market size of agricultural sub-sectors in India (year 2011)

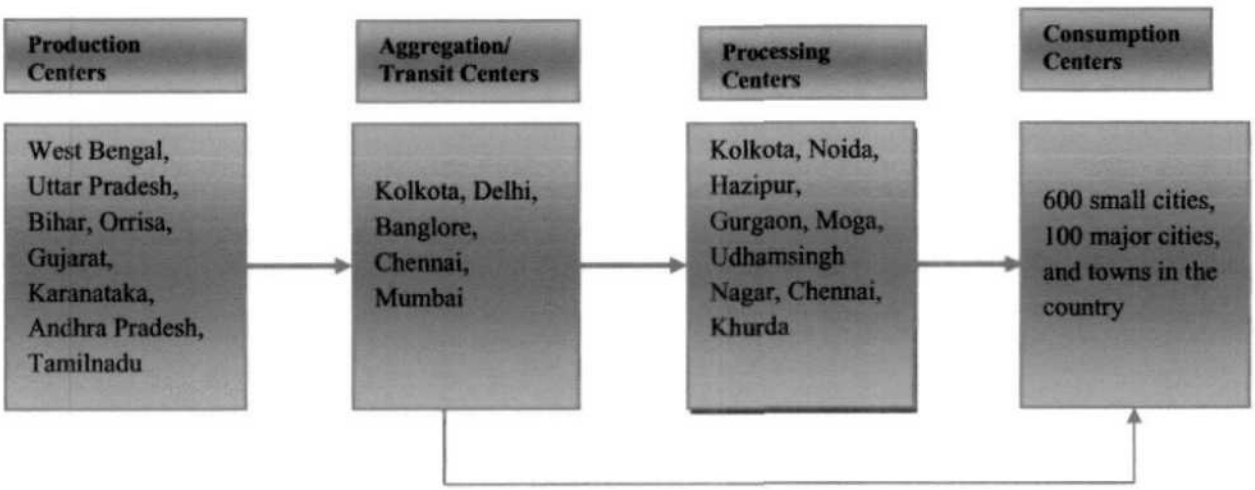


Source: Multiple sources

[7]Backward and forward linkages are descriptive measures of the economic interdependence of industries in terms of magnitude transactions. A sector's linkage through its direct and indirect purchases is called its backward linkage. As reverse to backward linkage, a sector is forward linked to other sectors through its direct and indirect sales to them (Cai and Leung, 2002).

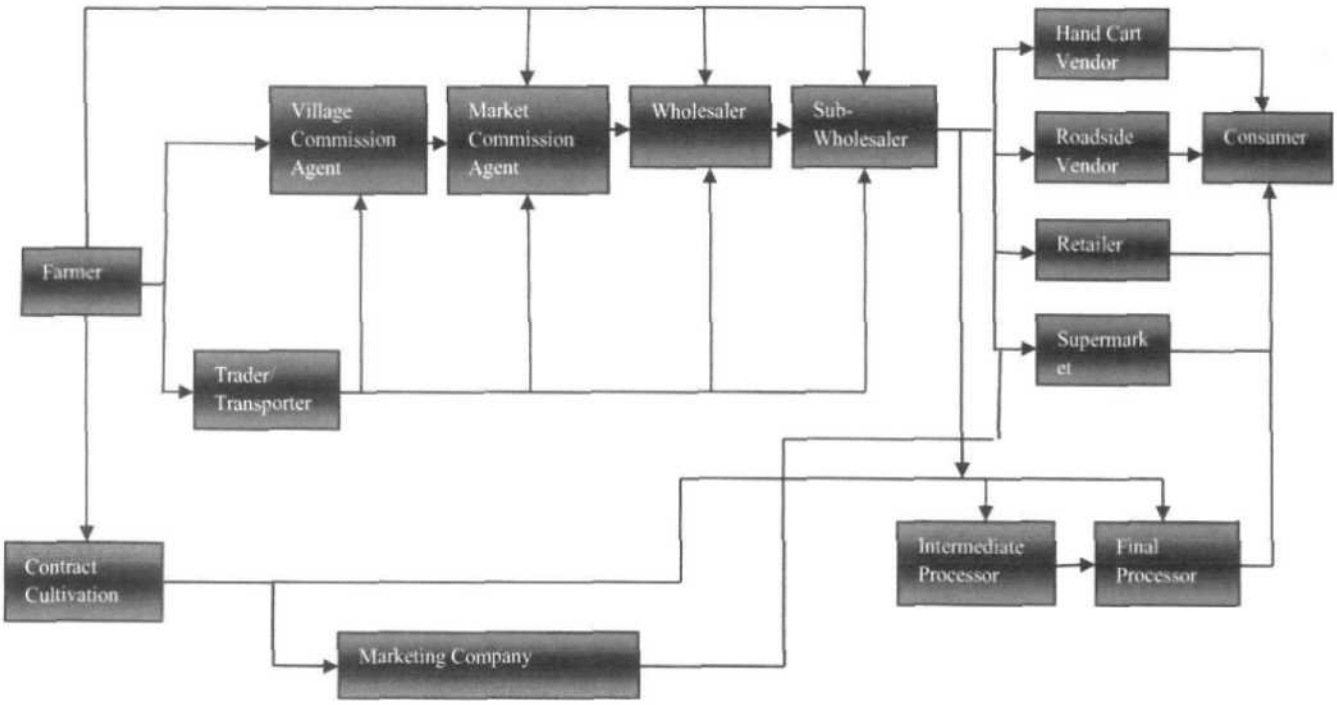
Vegetable Map of India: Eight major producing states contribute to >70% of total vegetable production in India

Figure 1.4c: Vegetables hub-centers across country supply chain



As recognized by the relevant literatures, the high value vegetable supply chains are the most complex; least developed, and involves numerous stakeholders at various stages: farmers, village/ market commission agents, wholesaler/sub-wholesalers, food manufacturers, vendors, retailers, and multiple intermediaries who add cost but no/little value to the product (Figure 1.4d). The infrastructure connecting these stakeholders is very weak leading to huge wastage along the chain. The storage and the distribution networks are at worst, so whenever there is even a small supply shock or a small demand shock prices are going haywire. Further, marketing of vegetables are challenging because of the perishability, seasonality and bulkiness and consumption habits of the Indian Consumers. In addition to this, poor equity in supply chain and conventional small scale unorganized retailers, make state of the art supply chain challenging in the present scenario.

Figure 1.4d: Vegetable supply chain in India (covers all possible stakeholders)



As a result, more than 50 percent of produce losses and wastage in the supply chain operations (FAO, 2011). Also, despite accounting for 15 per cent of world's vegetable production, India has a relatively low, less than 2 percent of the total vegetables produced in the country are commercially processed and exported (Ernst and Young, 2009). The sub-optimal performance of vegetables' supply chain is largely due to inefficiency caused by high potential risks across the supply chain. The upward

vegetable supply chain is the most risky in a number of ways, including the quantity and quality of production and the costs and, in some cases quality and availability, of essential inputs, such as seed, fertilizers, irrigation water (Rao, 2008; Barnett and Mahul, 2007; Turvey, 2001; Goodhue and Simon). Post-production crops are greatly suffers from poor logistics & transportation, poor handling, lack of processing techniques, lack of quality control practices, and storage (Basavaraja et al., 2007; Rajagopal, 2002). Vegetable marketing introduces additional sources of risk, including price risk, policy risk, and "placement risk" (defined as the risk of not finding a buyer for all or part of one's production) (Vaswani, 2011; Shilpi and Umali-Deininger, 2007). Broadly, the vegetables risks can be classified according to their supply chain phases, which are consists of input, production, post-harvest, and marketing& price (Ali and Kapoor, 2008; Skees et al., 2006; Mirinda and Vedenov, 2001; Boehlje and Eidman, 1994).

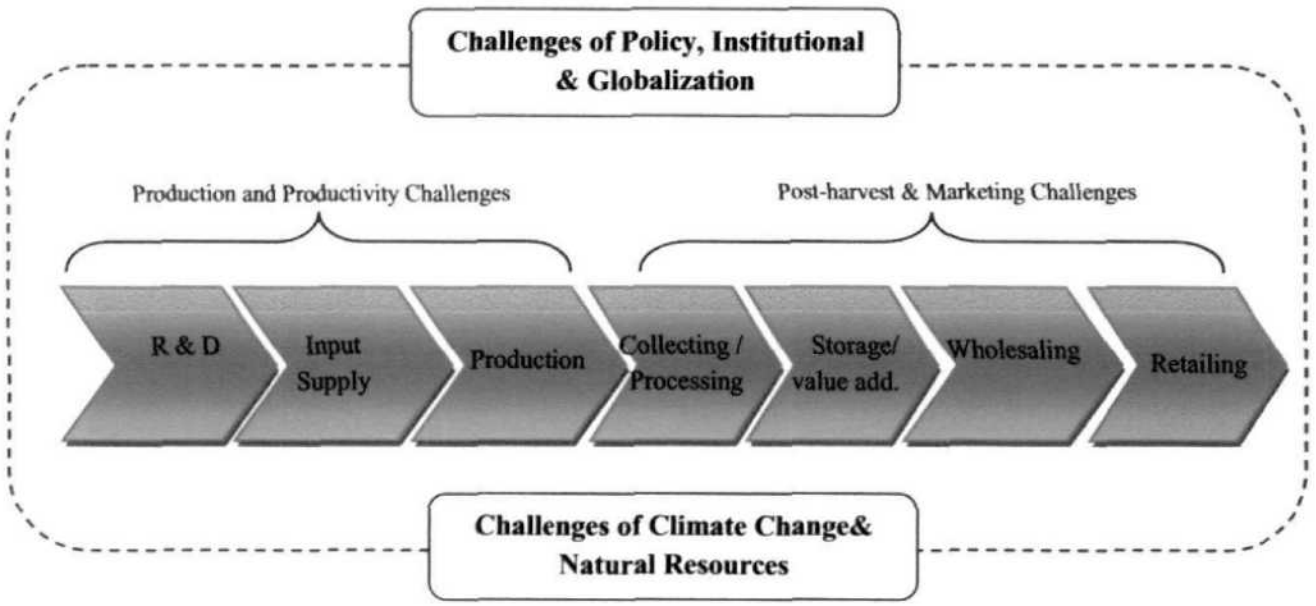
Managing vegetables risks are critical to achieve the sustainable agricultural growth, food & nutritional security, and improve rural livelihood situation.Recent approaches and developments have the potential to manage the high potential risks facing the vegetable enterprises and its supply chain. Managing risk across the chain not only helps in cutting costs, but also adds to maintain and improve the quality of vegetables market. Identifying these advancements and their relevance to the current needs of millions of smallholder vegetable farmers and other stakeholders including consumers will strengthen and efficient the country's vegetable supply chain.

The profound changes in food consumption behaviours and future demand for growing population pose challenges to respond the agriculture with shrinking natural resources and ever increasing agricultural risks. Overall, the agriculture growth performance is non-satisfactory; which may have wider, long-term and serious ramifications that can seriously impact food and nutritional security and undermining the poverty alleviation goals of the country. For agricultural growth to occur at the rate required to meet future quality and quantity demand, there is strong need to understand and respond the emerging risk and challenges of 21st century agriculture.

1.5 Problem Statement – Emerging Risks and Challenges across High Value Agriculture Supply Chain

In the 21st century, Indian agriculture has been experiencing a deceleration and is confronted with new challenges causing agricultural performing at much below to the actual potential of the country. Figure 1.2b depicts the divergence between the growth trends of the total economy and that of agriculture & allied sectors during a span of about 60 years. Growth in agricultural GDP decelerated from over 3.7 percent per annum during early reform period (1991-92 and 1996-97) to only 2.5 percent during ninth & tenth plan period Slowdown in agricultural growth can largely be attributed to a variety of risk factors such as declining public investment, degradation of natural resources, failure to carry out essential reforms to conserve water and soil, weak rural infrastructures, markets inefficiencies, adverse impact of trade liberalization, disease outbreaks, limited extension and financial services, unabated and weakened support systems and climate change (Ali and Kapoor, 2008; Cottern et al, 2008; Chong, 2005; Hardaker et al., 2004). Agriculture sector has also been widely neglected for decades by donor to developing countries' as total overseas development assistances allocated to agriculture dropped from 15% in 1980s to less than 3% in 2007 (World Bank, 2007; Global Donor Platform for Development, 2008).

Figure 1.5: Challenges across agriculture supply chain in India



The agricultural situation in the country has become more volatile, competitive, knowledge-led and market-oriented over the years (Singh and Sharma, 2004). It is evident from the fact that unlike the overall economic growth pattern, agricultural performance in India has been quite volatile (measured in terms of Coefficient of Variation, CV) during 2000-01 to 2010-11 was 1.5 compared to 1.2 during the previous decade (1990s) (estimated from CSO 2012 database for agricultural GDP growth). This is almost five times more than the CV observed in the overall GDP growth of the country indicating that agriculture sector, which is characterised by risk is becoming an ever riskier posing serious challenges for agricultural supply chain and its external environment (Figure 1.5). The major supply chain challenges are at the front of productivity, production, post-harvest and marketing. While external environment challenges arises mainly from Policy, Institutional Environment & Globalization including most serious challenges of climate change and depleting natural resources.

1.5.1 Challenges of Agricultural Policy, Institutional & Globalization

Traditionally, India's agriculture development was based on protected policy environment, which included controls on farm inputs, production, market, pricing, trade, storage, transport, and quantitative restrictions on foreign trade. During 1970s huge public investments were made for creating basic agricultural infrastructure such as irrigation facilities coupled with research and extension to augment food production by increasing cropped area and productivity. These policies were primarily intended to attain long-term food security and stabilize agricultural prices. Notwithstanding, agricultural policy had been dynamic in nature. Institutions were created while others were disbanded depending on the exigencies of the time. However, present agricultural situation in the country is remarkably different from that of few decades ago, but too many of India's agricultural policies are still focused on earlier approach. Agriculture being a state subject for policy initiatives and regulations, there has always been overlap of institutional mechanism across the agricultural systems.

Indian agriculture is facing a policy paradox in the era of globalization with serious challenges of declining productivity, climate change, volatility in prices, shrinking farm size and maintaining global quality & safety standards for agricultural trade (Sinha, 2009). Globalization policies of 1990s and beyond have created many challenges for agriculture sector in the country, which has consequences and impacts in

terms of diversification of domestic production systems, vertical integration of the food supply chain, increase in demand for high value food, declining agri-food export, rising food imports, domestic agriculture exposure to international market, and competitiveness (Pinglai, 2006). Today's main policy challenges are improving productivity and moving towards high-value agriculture and promote rural non-farm sector by maintaining food security for reducing poverty and hunger.

The environment for Indian agriculture and policy is changing fast. The public investment in agriculture sector declined from 3.4% of agricultural GDP in the early 1980s to 1.9% in 2001-03 (Mani et al., 2011). In terms of composition, the share of public investment[8] in total investment decreased significantly over time from about 50% in the early 1980s to less than 20% in the decade of 2000s (Dev, 2012). In other words, the share of private investment increased from about 50% to 80% during the same period. Likewise, overseas development assistances allocated to agriculture is dropped from 15% in 1980s to less than 3% in 2007 (World Bank, 2007). Regarding procurement policy, the Commission for Agricultural Costs and Prices (CACP), which recommends prices for many important crops in considerations of cost of cultivation, global and domestic prices, demand and supply etc. is helping only few crops and few regions in the country. Also, the current policies suppot do not appear to be meeting the key policy goals of protecting marginal and small farmers. These declines in public investments and overseas contribution have been matched by poor performance of agriculture and disappearance of agricultural research systems and other supports. Also, agricultural policy also lack in the strong government commitment to implementing basic social protection measures for small farmers and poor consumers. However, to provide new direction to agriculture, the central government launched National Agricultural Policy in 2000 aiming at tapping the vast untapped growth potential of Indian agriculture and attaining the agricultural growth of 4 percent per annum.

Various mission mode programmes such as National Horticulture Mission, Cotton Mission, Oilseeds and Pulses Mission etc were launched by the Government. However, due to lack of proper institutional mechanism, the expected benefits couldn't be realized. The existing institutional support mechanism for Indian agriculture is also grossly inadequate to meet challenges of 21st century agriculture. The weak institutions

[8] It may be noted that 90% of the private investment is made by farmers for on-farm production.

for managing, coordinating, overseeing, and monitoring seriously hinder the attainment of an evidence-based and inclusive policy process. There is strong need to change and strengthen the entire range of institutional arrangements whether they are concerned with use of natural resources, inputs, marketing and trade or R&D and transfer of technology. Considering the outstanding performance of some non-government organizations (NGOs) and community organizations of farmers, it is imperative to involve them in the new institutional arrangements. There can be better ways of more efficient food management practices in procurement, buffer stock and public distribution system (PDS).

1.5.2 Challenge of Climate Change and Natural Resources

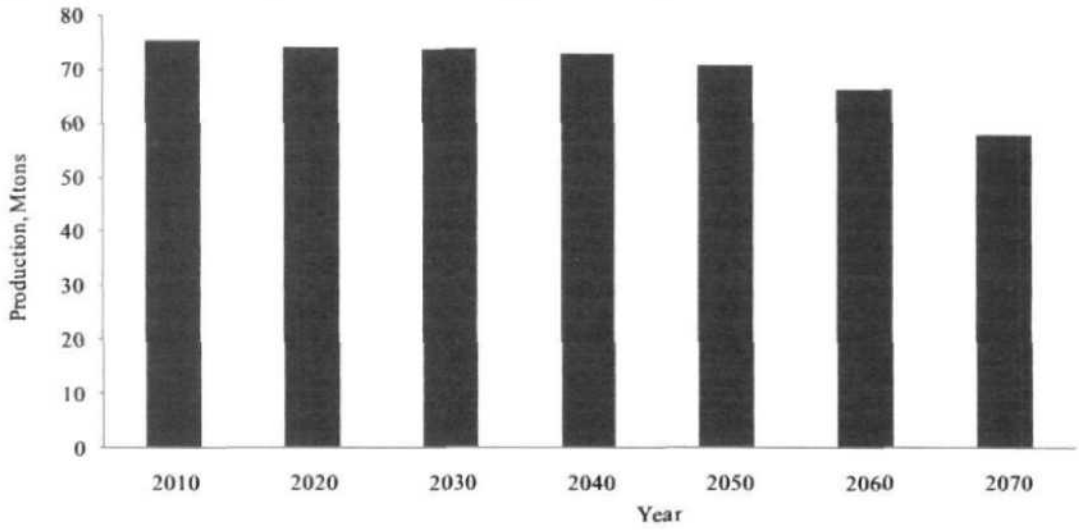
Climate change, resulting mostly from global warming, has been among the major challenges facing agriculture today. Extended drought periods and heavy rainstorms are becoming common features of the weather (Met Office 2005). The agriculture sector in developing countries is the most vulnerable to climate change as compared to developed one, because they have fewer resources to adapt in all sorts: socially, technologically and financially (UNFCCC, 2007). According to FAO (2005) estimates for developing countries, 11 percent of arable land could be affected by climate change, including a reduction of cereal production in about 65 countries, about 16 percent of agricultural GDP. This has raised fears that the world, particularly developing countries, may not be able to grow enough food to ensure that future population are adequately fed (Harris and Kennedy, 1999).

In India, while there is considerable uncertainty as to how climate change will affect specific regions in the country, the general consensus at present is that temperatures will rise through most of this century and many parts will experience a reduction in average annual rainfall, while some regions may face drought. Some simulation studies on the impact of climate change on major foodgrains like rice and wheat yields indicate that a 2°C rise in mean temperature may reduce the potential grain yields of both the crops by about 15-17% in north India (Kaur and Hundal, 2007; Aggarwal and Sinha, 1993). Another study by Geethalakshmi and Dheebakaran (2008) shows that temperature and precipitation changes may reduce the rice yields (during the kharif season) by 10-15 percent by 2020 in the state of Tamil Nadu. By 2050, the

magnitude of yield decline would aggravate further to 30-35% (Kumar and Nath, 2010).

At the country level, a substantial decrease in wheat production is likely to occur if the existing pattern of climate change continues. After incorporating the climate change effect, the wheat output is projected to barely reach 75 million tonnes in 2020 (as against projection of nearly 100 million tonnes without considering climate change impact). Beyond 2020, wheat yield have been projected on the basis of input growth are unlikely to materialize and the production would come down sharply (Figure 1.5.2). The adverse effect of climate change on short duration crops and perishable items such as fruit, vegetables and spices, due to high environmental susceptibility of these crops, have also been reported (Sivakumar and Stefanski, 2008). Similarly, due to high sensitivity of livestock and marine production to climate change, the livestock productivity is also expected to decline, which may have adverse consequences to nutritional security (Sirohi and Michaelowa, 2007).

Figure 1.5.2: Possible impact of climate change on wheat production in India



Source: NATCOM, 2004(adopted from Dasgupta and Sirohi, 2010)

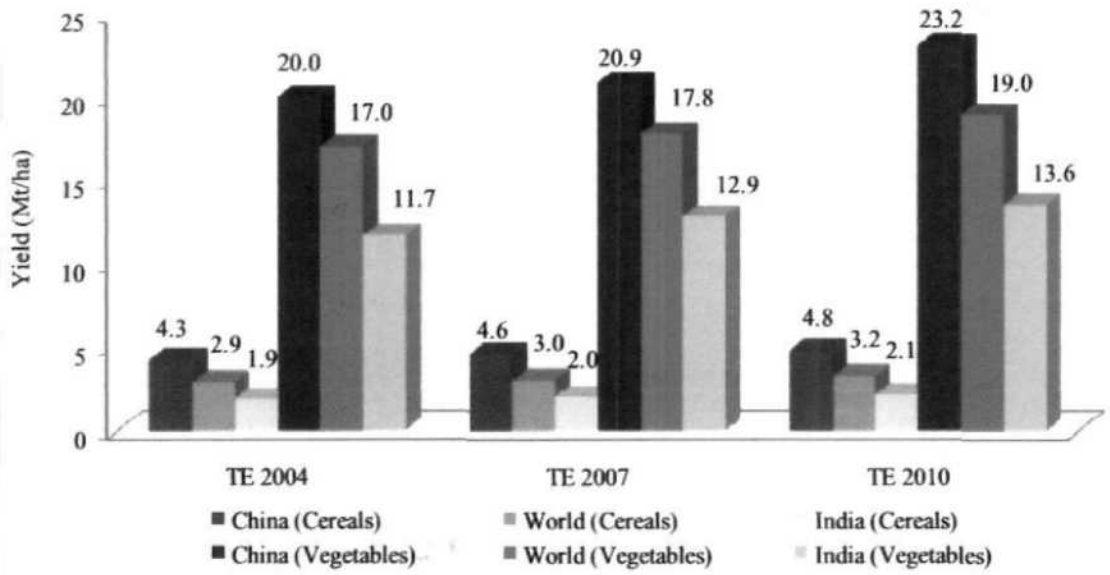
Apart from the climate change, the degradation of natural resources particularly soil erosion & loss of soil structure, reduction in soil organic matter, falling ground water tables, drying rivers or floods, and pollution are alarming about the decline in future food supply. Also, per capita land availability in India has declined from 0.89 hectare in 1951 to 0.3 hectare in 2001 while during the same period; per capita availability of agriculture land has declined from 0.48 hectare to 0.14 hectare (Ministry

of Environment & Forest, GoI[9]). The declining availability of per capita land resources is further exacerbated by degradation and desertification of land. Thus, the likely impact of climate change and diminishing natural resources on food production and productivity in India can constrain attainment of future food security from the domestic production.

1.5.3 Production and Productivity Challenges

Agricultural production in the country has moved through various stages during last 60 years and now showing stagnation in the recent years. Due to this stagnation in agricultural growth, the time has come to develop innovative technologies related to seed, fertilisers, irrigation system and good agricultural practices, for promoting important crops which are more productive, profitable, cost-effective, sustainable, and resilient. One of the main problems of Indian agriculture is its low productivity as compared to global averages (Figure 1.5.3a). Indian agricultural yields are among the lowest in the world, although there has been marked improvement in per hectare yield since 1950-51. The world average yield for cereals is 152 percent higher than Indian yield. Similarly the world average yield for vegetables is 146 percent higher than Indian yield for the same.

Figure 1.5.3a: Yield of cereals & vegetables – A comparison



Source: FAOSTAT

[9] http://www.envfor.nic.in/divisions/ic/wssd/doc1/chap6/da_page_6_1.htm

The main cause of this low per hectare yield is low fertility of soil and less care to replenish it through balanced use of artificial fertilizers. Soil erosion is not only a major cause for decreasing soil fertility but also the loss of valuable cropped land. Table 1.5.3a presents the soil fertility maps of India which is based on systematic survey and analysis of more than 2.5 lakh soil samples conducted by the All India Coordinated Research Project (AICRP), indicating deficiency levels in the soil. It clearly shows that about 63 percent of soils are low, 26 percent of soils are medium and only 11 percent of soils are high in available nitrogen. Similarly, about 42 percent, 38 percent and 20 percent soils are low, medium and high, respectively, in the availability of phosphorus. About 50 percent soils are high in potassium, 37 percent medium and only 13 percent low in potassium. The deficiency level of Zn was to the extent of 49%, 33% of B, 13, 7 & 4% of sample rating low in Fe, Mo and Mn.

Table 1.5.3a: Extent of nutrient deficiency in Indian soils

Nutrient	Extent of deficiency
N	**L 63%; M 26%; H 11%**
P	L 42%; M 38%; H 20%
K	**L13%, M 37%; H 50%**
S	L 40%; M 35%; H 25%
Zn	**49%**
Fe	13%
B	**33%**
Mo	7%
Mn	**4%**

Source: ICAR

With intensive cropping system using only NPK fertilisers and with limited use of organic manures, soils became deficient in a large number of elements (Figure 1.5.3b). In India, about 80 million hectares of cropped area is facing the problem of soil erosion. Planning Commission (Govt of India) recognized the specific regional constraints attributed to low productivity in the concerned states (Table 1.5.3b).

Figure1.5.3b: Emerging deficiencies of plant nutrients vis-a-vis increased foodgrains production

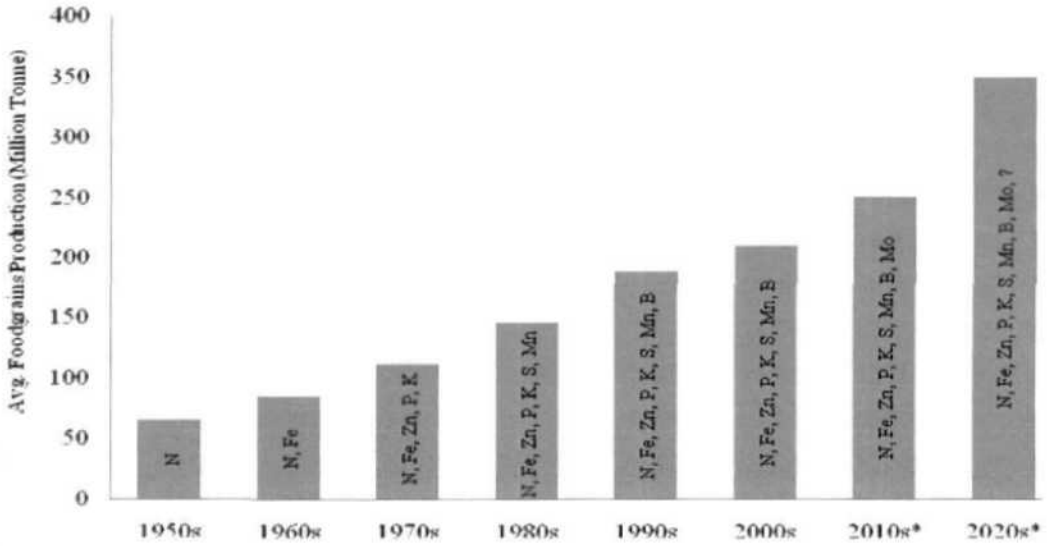


Table 1.5.3b: Region specific factors that can be attributed to low productivity

Agro-climatic region	States/parts of states	Region-specific constraints
Western Himalaya Region	J&K, HP, Uttarakhand	Severe soil erosion, degradation due to heavy rainfall/floods and deforestation, poor road, poor input delivery, inadequate communication infrastructure and marketing.
Eastern Himalayan Region	Assam, NE States, Sikkim	Aluminium toxicity and soil acidity, soil erosion and floods, shifting cultivation, non-availability of electricity, poor road, poor input delivery system and communication infrastructure.
Lower and Middle Gangetic Plains Region	West Bengal, Bihar, Eastern UP	Flood/water logging, improper drainage, salinity/alkalinity, arsenic contamination, Non-availability of electricity, high population growth, poor road and communication infrastructures.
Upper and Trans-Gangetic Plains Region	Western UP, Punjab, Haryana	Groundwater depletion, decreasing total factor productivity, micronutrient deficiencies, inadequate-availability of electricity, and high population density
Eastern Plateau and Hills Region	Orissa, Jharkhand, Chhattisgarh	Moisture stress, drought, soil acidity, iron toxicity, non-availability of electricity, high population growth, poor road, poor input delivery and communication infrastructure.

Source: Planning Commission

1.5.4 Post-harvest and Marketing Challenges

While increasing productivity and production are essential components of a vibrant agricultural sector, improved post-harvest[10] practices and marketing are also essential to

[10]A post-harvest system is concerned with the post agricultural agro-industries sphere and includes technologies of storage, transportation, and processing of agricultural raw materials into food products (Meliczek, 1985)

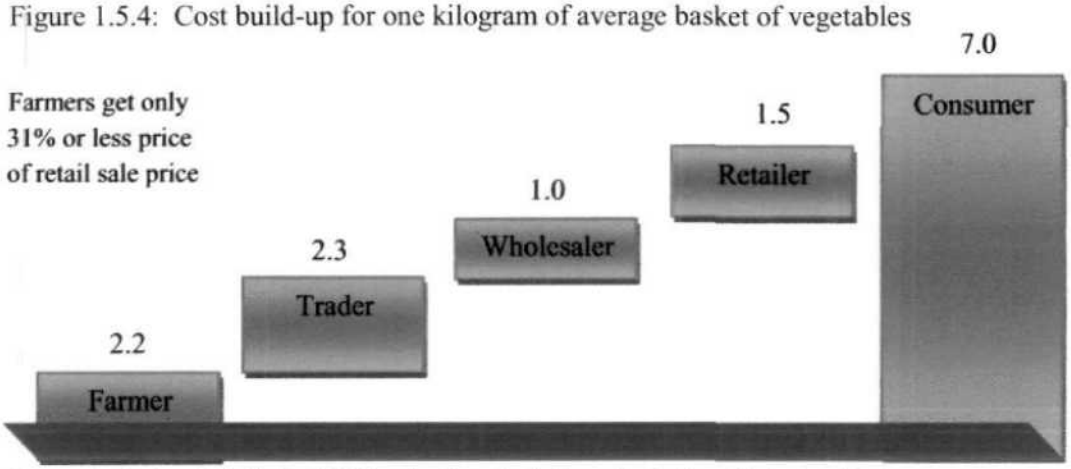
ensure high-quality products reach the markets and farmers' income gain. The existing post-harvest practices in the country are one of the major concerns, causing huge post-harvest losses particularly of perishable items such as fruits and vegetables. It has caused losses in production, inputs and valuable nutrient quality. The sub-optimal growth of food processing and inefficiencies in marketing including and poor institutions in India is another constraint contributing to high losses and wastage of the farm produce, which translate into less income for farmers and the higher prices for the consumers.

Agricultural marketing in India is highly unorganized and inefficient. Marketing in agricultural commodities is assuming increasing importance in the wake of ushering in second green revolution, improving the living standards of farm families, making India hunger free and turning poverty into history in the shortest possible time. The challenges facing the marketing system are quite different than what these used to be about two decades before (Planning Commission, 2007). An efficient and organized marketing system is required to enable agricultural producers to build a platform where they can better market their produce. Such agricultural marketing system not only enables farmers to market their produce at local level but also explores avenues for the expansion of the market globally. However, there is need for intervention from various government and non-government agencies to act as catalyst in assisting farmers in marketing their produces both at local and global platform. Poor front end infrastructure such as storage facilities and improper warehousing facilities results in as high as 40-50% post harvest losses (however it varies from produce to produce) and wastage, which occurs across the entire food supply-chain from farm gate to consumer end. Imperfect market conditions and restrictions on the movement of agricultural commodities are not letting the farmers to realize the true value of their produce, whereas it is causing the consumer to pay a much higher price than warranted. There is limited access to the market information (generally blocked by intermediaries), and multiple channels of distribution that eats away the pockets of both farmers and consumers.

The 4Ps - price, product, place and promotion is the core principle of marketing but in the case of agricultural marketing in India it is not exactly the marketing in the literal sense and we can call it as 'distributive handling' of agricultural produce as there

are number of intermediaries involved who adds cost but no value to the product. The escalation in the cost of the produce is to an extent of 250 percent of the cost of production at the farm level and same is set out in the figure below (in case of vegetables) (Figure 1.5.4). However with the liberalization, privatization and globalization, the economic scenario in India has drastically and tremendously changed over the years. As a result, changes in the 'distributive handling' is being reinvented with the rise of retail giants who are the major buyers in bulk quantity and who constantly look for differentiated, graded, standardized, processed and packaged products rather than undifferentiated ones. The country need to develop an integrated mechanism linking the post-harvest and marketing activities that ensures the fast reach of perishable produce to market at the right time with right quality and quantity at right remuneration to the farmers.

Figure 1.5.4: Cost build-up for one kilogram of average basket of vegetables



Source: Agricultural Marketing Division for State Agriculture /Agriculture Marketing Ministers Conference (23.04.2008) by UKS Chauhan

History has shown that Indian agriculture can meet big challenges. There is sufficient evidence in the country itself that has shown that India come out from the high level of poverty and food-deficit nation to now food secure nation with surplus supply of food to the world. Between 1951 and 2011, the India's population increased by 335% (36.1 to 121 crores) and foodgrains production rose by more than 500% (from 50.83 to 254.4 million tonne), is a sufficient evidence of country's agricultural production capacity (Census, 2011).

The recent challenges for Indian agriculture in 21st century is to increase the productivity and production and remove the inefficiencies involved in post-harvest and marketing operations, in order to meet out the challenges posed by agricultural risks.

Risk affects both individual producers and the overall performance of the agricultural sector. At the productivity and production front, there is the wide gap between what the technologist gets in the experimental farm and what a farmer gets on his farm and also a wide gap between the "best-practice" farmer and the common run of farmers. At the post harvest and marketing end, significant loses and wastage of produce leads to quality and quantity losses in the food value chain. Minimising food losses and waste along the supply chains can make a big difference in improving the future food supply situation.

Small-scale farmers', who are the primary stakeholders in agricultural supply chain, constitute more than 70 percent of rural households (World Bank, 2007). Importantly, their importance can also be understood from that fact that they continue to contribute significantly to the agricultural production, food security, and rural poverty reduction in the country. However, they confront with new challenges in accessing the productive resources, integration into high value chains, adaptation to climate change, and market volatility and other risks and vulnerability. Also, they face multiple sources of risk arising due to the vagaries of weather, increasing cost of inputs, limited access to credit & crop insurance, lack of infrastructure & storage facilities, low economies of scale, lack of bargaining power, poor market linkages, lack of market information, market price fluctuations of produce, globalization of chains, and the unique political economy of food in domestic and international settings (Cottern et al, 2008; Tang, 2006; Chong, 2005; Hardaker et al., 2004). Further, emerging demand for high-value food commodities raised question whether the smallholders would be able to participate in such a fast changing commercial agriculture (Joshi et al. 2004; Kumar et al., 2003).

High-value agricultural commodities often characterized by perishable in nature, irregular supply of products due to seasonability of production, high income elasticity (hence growing demand), price sensitivity to quality & safety, and also market prices are highly volatile; the small-scale producers generally feed the local markets that are usually thin and fragmented. Marketable surplus of an individual small-scale producer is too small to be bargained and traded remuneratively in distant markets due to high marketing and transaction costs (Escobal et al. 2000). All these factors escalate the transaction costs and increase risks in production and marketing considerably that may again discourage the smallholders. Some generic constraints also

includes weak and/or non-existent farmer organizations, low levels of agricultural education and social capital, lack of vertical co-ordination, limited technical and marketing expertise & knowledge. Such constraints have resulted in a concentration in the supply base with large farmers, and enterprises, and a resultant decrease in small-scale farmers' involvement. Managing risks is critical for agricultural growth and development. Managing risk, typically, involves the use of a range of practices, techniques and tools in order to counter the risk across the agricultural chain (Ali and Kapoor, 2008; Miller et. al, 2004; Clark, and Brinkley, 2001).

India's agricultural supply chain is still predominantly unorganized; there are several inefficiencies due to potential risks involved at its various functions. There have been several attempts to manage this – from government, NGOs, Community Organizations, private agencies, and research institutions. Though, there has been some success in these attempts, these have not scaled up fast enough to manage the chain across diffident commodities efficiently and effectively. Given the complexity of agricultural production and post-harvest operations & marketing activities; coupled with the problems of poor agricultural practices and lack of infrastructure and deprived support mechanism, there is an urgent need to innovate and adopt quick & practical solutions. Organizing resource poor farmers and linking them into an integrated and effective supply chain framework/system, which comprise of efficient market and institutional support system may help to find out the solutions for effective agricultural risk management and to respond the 21st century challenges for efficiency gain in agricultural supply chain.

1.6 Objectives of the Study and Research Questions

This study aims at providing a generic and integrated framework for the systematic management of potential/ critical risks in the supply chain with special reference to upstream vegetable supply chain. The overarching objective of this study is to investigate the clustering approach of managing risks in upstream vegetable supply chain in India. Additionally, this study examines factors that affect the identification and treatment of potential/critical supply chain risks.

This study has been conducted with the following specific objectives and is expected to address the specified questions mentioned against each objective:

1. **To review the literature on risk and risk management in agriculture; and develop an integrated framework of supply chain risk management;**

   The research questions expected to be answered: 1) what are the existing approaches to classify agricultural risk? 2) what are the sources of agricultural supply chain risks? 3) what are various agricultural risk management approaches and mechanisms? 4) What is the research gap on existing literature on risk management?

2. **To analyze the transition and structural shift in Indian Agriculture and discuss the emerging trends towards the high value agriculture and mapping the vegetable value chain;**

   The research questions expected to be answered: 1) what are the trends in high-value agriculture in terms of area, production, productivity and value of ouput? 2) Examining India and Uttar Pradesh as the vegetable basket of world and India respectively. 3) what is the emerging structure of high value supply chain specially for vegetables?

3. **To identify, assess/evaluate and prioritize the various sources of risk in upstream vegetable supply chain; examine the disruptive ranges of critical risks across the chain.**

   The research questions expected to be answered: 1) what are the potential sources of risk in the vegetable supply chain comprised of input, production, post-harvest harvest, and marketing & price? 2) what is the difference in the realization of risk to cluster and non-cluster producers? 3) what are the critical sources of supply chain risks and measure their disruptive ranges?

4. **To discuss the clustering approach to manage potential/critical risks across upstream vegetable supply chain, and compare the risk control strategies of cluster and non-cluster farmers;**

   The research questions expected to be answered: 1) why clustering is an effective approach of risk management? 2) what are the major steps and activities/task of the clustering approach? 3) what are the differences in critical risk management strategies of cluster and non-cluster producers?

. **To review of risk management (minimization/reduction) within and between cluster & non-cluster across the vegetable supply chain as a result of risk control actions.**

The research questions expected to be answered: 1) what is the importance of risk review? 2) what are the results of adoption of risk control measures? 3) compare the risk minimization/reduction between of cluster and non-cluster producers.

6. **To investigate the factors affecting identification of critical risks and its management.**

The research questions expected to be answered: 1) what are the socio-demographic factors that affecting the identification of critical risks across supply chain? 2) what are the socio-demographic factors that affecting the management of critical risks across the supply chain?

ıe underlying premise of the study is that agricultural growth in India can be achieved by managing potential risks of high value agriculture across the supply chain through an integrated approach of risk management which integrate farmers' (particularly small-scale producers) in the supply chain and also promotes adoption of effective risk control measures.

1.7 Thesis Outline

This thesis is structured into eight chapters as per given descriptions below:

Chapter : 1 Introduction

This chapter presents the background and interest of this research. It critically reviews the growth performance of Indian agriculture since independence and briefly discusses the twists and turns during the plan periods. It also analyses the transition and structural shift in Indian Agriculture. Further, it critically examines India and Uttar Pradesh as the vegetable basket of world and India respectively. The chapter also maps the emerging high value supply chain structure in the country with special reference to vegetables. Then, it describes the statement of problem in terms of risk and challenges facing Indian agriculture in its transition to sustainability phases in the twenty-first century. In addition, this chapter

describes the detailed objectives, research question, and the structure of this dissertation.

Chapter : 2 Review of Literature and Theoretical Foundation

This chapter provides review literatures relevant to the research objectives. It builds a theoretical foundation upon which the research progresses. Commencing with the description of the concept of risk and risk management, it discusses the relevant literature on risks and uncertainty in agriculture in order to develop a better understanding of the issue. Further, it critically provides literature on sources of risks and risk management approaches & strategies. The review provides the theoretical foundation to this research.

Chapter : 3 Conceptual Framework and Research Hypotheses

This chapter introduces the conceptual framework of integrated supply chain risk management in agriculture and discusses hypotheses predicting the relationship and effect of clustering approach and socio-economic factors on managing potential risks.

Chapter : 4 Data and Methodology

This chapter provides a description of the data and methodology used in this study. Briefly, it discusses about the sampling procedure for data collection, survey instrument, and data analysis procedures and techniques employed in the study. The socio-demographics and farm characteristics of the sample are also summarized.

Chapter : 5 Results and Discussion

This chapter is divided into two major sections A & B.

The section - A presents a systematic approach of managing risk across vegetable supply chain based on primary data collected from the field survey. It starts with the analysis for the identification and assessment of various sources of risk across the vegetable supply chain. Then, it prioritizes the risks using Pareto Analysis and identifies the critical risks in the supply chain. In addition, it investigates various factors that affect the identification of critical risks.

The section - B analyses the clustering as an integrated approach for managing potential/critical risks across the vegetable supply chain, and

also compares the risk control strategies of cluster and non-cluster farmers. Moreover, it investigates the factors affecting management of the critical risks in supply chain. Lastly, it evaluates the impact of clustering on risk minimization / reduction and put observations on the same.

Chapter: 6 Conclusion, Implications and Recommendations

This last chapter ends this thesis with the conclusions drawn as well as their implications. It also provides practical recommendations for actions arise from the findings and observations of this research study. Also, it hints opportunities for further research.

Chapter 2

REVIEW OF LITERATURE AND THEORETICAL FOUNDATION

The main aim of this chapter is to provide comprehensive review of literature relevant to the research objectives. It builds a theoretical foundation for undertaking this research. This chapter commence with describing the concept of risk and risk management in general and in agricultural context. Further, it critically reviews the literature on sources of risks and risk management across agricultural supply chain and finally identifies the research gap.

2.1 Concept of Risk and Risk Management

A study on risk management typically starts with discussion on the concept and definitions to ensure consistency and avoid confusion in terminology. The concept of risk which traced back in 17thcentury is extensively studied in literature from different perspectives (Cucchiella and Gastaldi, 2006). Many authors, among others, Krimsky and Golding (1992), Otway (1992), and Pidgeon et al. (1992) argued that the concept of risk helps people to interpret and cope with dangers and future uncertainties. Risk and uncertainty are widely discussed issue in supply chain management literature and are often used interchangeably (Briggs, 2010). However, they are distinct concepts. Risk is often measured in probability terms i.e. when all the possible outcomes of an event with their objective probabilities are known, therefore risk can be quantified (McVean, 2000). In contrast, uncertainty is a situation when either all the possible outcomes or the probability of the outcomes are unknown or both the outcomes and the probabilities are unknown (Hardaker et al., 2004; Oslon, 2004; Knight, 1921). Miller (1992) and Davis (1993) used the term uncertainty for unpredictable nature of operating environment, and key issues in managing supply chains. Risk is often identified to be the consequence of uncertainty (Lalwani et al., 2006).

The definitions of risk are multifarious and range the spectrum, where few focus primarily on the likelihood of bad events occurring (Zsidisin, 2003; Dowling and Staelin, 1994; Forlani and Mullins, 2000). British Standards Institute (BS 4778, 1991)

defines risk as a 'combination of probability or frequency of occurrence of a defined hazard and magnitude of the occurrence'. Sitkin and Pablo (1992) define risk as 'the extent to which there is uncertainty about whether potentially significant and/or disappointing outcomes of decisions will be realised.' Therefore, risk reflects both the range of possible outcomes and the probabilities for each of the outcomes. MacCrimon and Wehrung (1986) identified three basic elements of risks: probability, exposure and consequence. An important element in the evaluation of risk is the ability to precisely determine the probability of an outcome (Conchar et. al., 2004)). An established measurement of risk is based on the probability or frequency of an event and the magnitude of the impact of the event (Jia et. al., 1999). Quantitatively this can be represented as the product of Probability and Impact (Pich et. al., 2002; Weber and Milliman, 1997). Risk, in general, can be defined as a collection of pairs of probability (or likelihood) (L) and outcomes (or impact) (O):

Risk = {(L1, O1), (L2, O2),..., (Ln, On)}
(where Oi and Li denote outcome i and its related likelihood respectively)

The distribution pattern of the (likelihood; outcome) pairs is called as risk profile (Ayyub, 2003). In laymanterm, risk is normally associated with simply negative outcomes and losses (Nath, 2011; Manning and Gurney, 2005; Deshmukh, 2007).

Managing risk involves understanding the two dimensions of risk (probability and impact) and taking action based upon them. Therefore, risk management involves reducing, minimizing and controlling the probability and impact of negative occurrence, and/or increasing the probability and impact of positive occurrence. A risk management process typically starts with identification of sources of risk followed by quantification/analysis and ends with the mitigation of risk through the risk response development. Risk quantification is simply the multiplicity of probability (likelihood) and impact (consequences).

2.2 Risk and Uncertainty in Agriculture

Understanding agricultural risks and uncertainties are crucial in the context of their impact on agricultural production and livelihood, which affects massive rural population directly or indirectly, particularly in developing countries like India (Birthal, 2004). A number of empirical and theoretical studies have been undertaken to

understand the complexities and risk of agricultural sector (Ali and Kapoor, 2008; Raju and Chand, 2008; Swati et. al., 2008; Turvey, 2001). Agriculture sector involves natural and economic reproduction, and it is influenced by a series of natural, economic and social factors, making it as high risk business (Hardaker, 2000; Hardaker and Hiurne, 2004). Empirical evidences acknowledge agricultural risk as a negative impact on outcomes, stemming from imperfectly predictable climatic, biological, geological, market and price variables (Jaffee et al, 2010; World Bank, 2005; Barnett, 2005; Hardaker, 2000). Few studies have also considered agricultural risk as an uncertain event that can lead to farmers' welfare losses (Vaswani, 2011; Rao, 2008; Ali and Kapoor, 2008). Agricultural risks can range from independent with local level impact to highly correlated risk resulting losses to communities at large (World Bank, 2011). The independent risks may include localized hail losses, an individual farmer's illness or death while highly correlated risks may include drought, flood, declining commodity prices, rising input prices, or market collapse.

The farm producers, particularly in developing countries, operate in an uncertain decision-making environment, where they are plagued by imperfect knowledge and information while deciding what, when, how and where to plant crops (Nath and Ahmad, 2011; Ali, 2008). Imperfect knowledge and information affects decision-makingas lack of information creates an ambiguous situation for a decision maker (Ghosh and Ray, 1997). In agricultural systems, risk is present in each and every management decisions, as a result of price, yield and resource uncertainty (Gomez-Limon et al., 2002). Risk taking requires confidence in decision choices. According to Heath and Tversky (1991), ambiguity can erode the confidence due to lack of information. The uncertainty also inherent in biological production process of crops such as weather, pests, and disease that are part of the natural resource endowment of any farm's environment (Bonnen and Schweikhardt, 1998). Risk associated with post-harvest crop losses in the processes of handing, storage, and transportation is of serious concern, impacting food security in developing and poor countries (Kumar and Nath, 2010). Farm producers are also exposed to uncertain access to markets and high price risks which often occur, or are accentuated by inefficiencies in markets or policy interventions (ESFIM, 2011).

A typical agri-food supply chain encompasses various stages of agricultural system such as input supply, production, postharvest, storage, processing, marketing and distribution and follows a 'farm to fork' structure. According to Grabowski and Roberts (1997), each individual supply chain entity is an autonomous enterprise, yet is also interdependent upon each other. A single impact at any point may affect the whole supply chain through disruption in flow of agri-food products, finance or information (Mishra, 2011; Juttner, 2005). One factor that complicates the situation and increases the magnitude of risks within supply chain is the perishability. Fruits and vegetables are highly perishable; therefore fruits and vegetables supply chain suffers from maximum inefficiencies (Ahya, 2006). Furthermore, agricultural supply chains in many developing countries comprises millions of small scale farmers (<2 ha), who are not well structured and organized in the supply chain. However, lack of proper strategies and inefficiencies in organizing an effective supply chain are resulting in huge value loss both in terms of quality and quantity for the large number of farmers.

The evaluation of literatures leads to the conclusion that the common features in the various paradigms relating to agricultural supply chain risks typically incorporate the issues of unpredictability, decision making and potential loss.

2.3 Approaches of Classifying Agricultural Risks

In literature, there are several approaches to classify risk and vulnerability sources (OECD, 2011; Asbjørnslett, 2009; Simchi-Levi et al., 2008; Acharya, 2006; Hardaker et al., 2004; van der Vorst and Beulens, 2002; Moschini and Henessy, 2001; World Bank, 2000; Harwood et al., 1999; FAO, 1997). Risks in agriculture, which perpetuate poverty and food insecurity, are both natural as well as induced by human processes (Acharya, 2006). Natural risks in agricultural have different origins: climatic/ hydro-meteorological (hail, drought, flood, landsides, frost, tornados, hurricanes, heat waves, and storm surges), biological (diseases and insect infestations), environmental (soil erosion, damages to flora and fauna), and geological (earthquakes, volcanic eruptions, and tsunamis) (Wenner, 2005; Zorilla, 2002; OECD, 2000). While man-induced risks can be traced to financial crises, collapse of legal institutions and changes in international trade and policy environment (Ondersteijn et al, 2006).

FAO (1997) broadly categorized agricultural risk sources in terms of external, which originate from outside the farm and internal sources of risk that arise inside the agriculture system (Koh and Saad, 2004). Major external sources of risk relate to uncertain turbulence in the natural, social, economic, policy and political environments in which the farm system has to operate (Van Landeghem and Vanmaele, 2002; Hardaker et al., 1997; Beal 1996; Fleisher 1990). Internal sources of risk mainly related to health or interpersonal relations between farm-household members as influenced by personality, changing values, attitudes and aspirations (Van der Vorst et al., 1998).

Harwood et al., (1999) classified sources of agricultural risks in terms of production, marketing, financial, and institutional. Ahmed (2011) added human resource risk in the above list. They described production risk resulting from uncertainty about the levels of production whereas market risk caused by potential volatility in input-output prices of crops. Market risk also includes uncertainties from the markets such as the conditions imposed by the contractors. Financial risk is related to the variability of interest rates or of the value of financial assets, and the non-availability of credit when required. Legal risk associated with legal responsibility of farmers in relation to their production and collapse of the legal institutions. Human resource risk is primarily related to lack of labour or skilled labour availability, family violence, illness or death of farm family members. Changes in policies and laws such as environmental requirements generate institutional risk.

Holzmann and Jorgensen (2001) and World Bank (2000) classified agricultural risks into three broad categories: micro or idiosyncratic risk, meso-risk or covariant and macro or systemic risk. Micro or idiosyncratic risks that affect individual farmer or household are related to field specific problems, illness or death of a family member. Meso or covariate risks affect a whole community or group of households. Macro or systemic risk affects whole region or country and related to factors such as war and financial crisis (Zhang et al. 2007, Okunmadewa, 2003).

Moschini and Henessy (2001) made a distinction by classifying sources of uncertainty in agriculture. They pointed out four important sources of risk - production, price, technological and policy uncertainty. Production uncertainty is due to quantity and quality of farm output that will result from a given bundle of production decisions

are not known with certainty. Price uncertainty is due to uncertainty about the prices of farm output at the time of production decisions are taken. Technological uncertainty can arise because of evolution of new production technique that may make quasi-fixed past investments obsolete. It may also arise due to the new technology, which is not demonstrated at the farm level. Agriculture particularly in developing is subject to high Government interventions. Consequently, any unfavourable changes in agricultural policy may create risk for agricultural investment.

Hardaker et al. (2004) and Hulme et al. (2000) differentiated between business risks and financial risks, can be used for most agricultural risks. Business risk includes production, market, institutional and personal risks. Production risk is due to unpredictable nature of the weather and to the uncertain performance of crops. Market risk is attributed to uncertainty in prices of farm inputs or outputs. Institutional risk is due to uncertainty about the impact of government policies on farm profits. Business risks furthermore include personal risks, which are related to uncertain life events such as illness or death of farmer. Whereas, financial risks refer to the risks related to the way a farm is financed. Moreover, financial risks may originate from rise of interest or due to unavailability of loan.

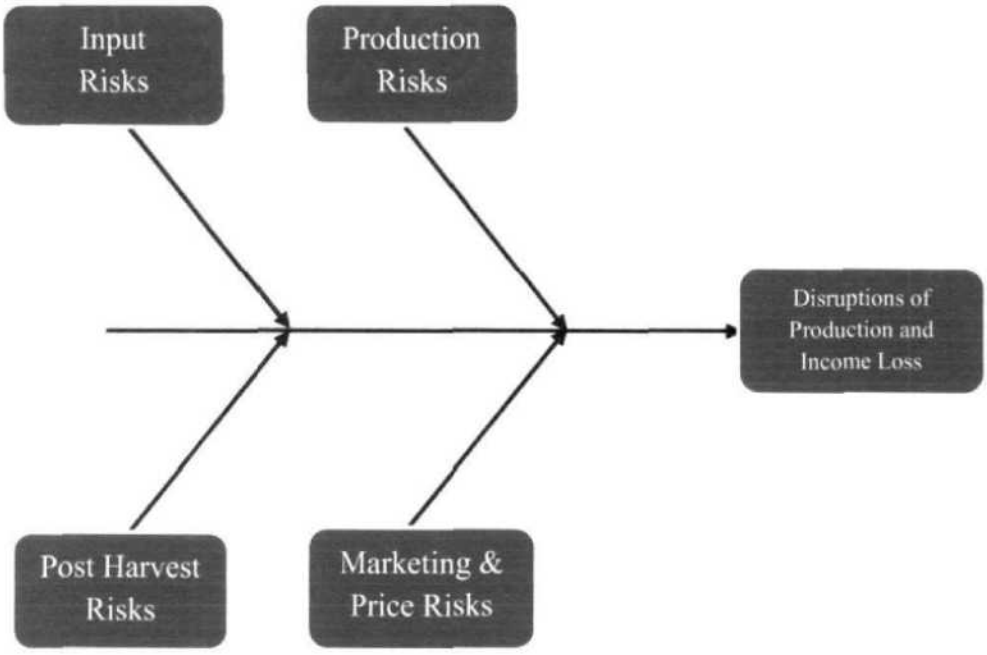
OECD (2011) study has identifies three layers of risk faced by producers as normal, marketable and catastrophic risks depending on frequency, scale, intensity, and duration. Normal risk is frequent but not too damaging such as small variations in price or yield. Marketable risks have intermediate levels of frequency and magnitude of losses such as hail damage. Both, normal and marketable risks can be considered as non-catastrophic affect localized areas or sometimes only a few farms. Agricultural catastrophic risks are related to extreme but infrequent events so have low-probability, but have relatively serious negative agricultural economic consequences (Lei and Qiaoa, 2010). Flood, drought or disease outbreaks are considered as major catastrophic risks.

Any classification of risks underlies the fact that an individual farmer faces different often simultaneous sources of risks across agricultural supply chain (Zsidisin, 2003). Risk sources as supply chain-related variables that cannot be predicted with certainty and that have impact on the supply chain performance (Juttner et al., 2003).

Current debate on supply chain risk is a holistic and an integrated approach to understand agricultural supply chain risks is relatively new field. Supply chain risk literature has emphasised primarily on the downstream or demand side of risk (Chopra and Sodhi, 2005; Lee et al., 1997). Downstream events are generated by customers, such as dramatic changes in food quality, variety and nutrition due increasing concern and awareness on food safety issues highlighted by mass media (Ali and Nath, 2009; Brewer and Rojas, 2008; Caswell, 1998). Consumers across the world are taking unprecedented interest in the way food is produced, processed and marketed and are increasingly expecting from the governments to introduce proper food safety mechanism to ensure that safe food reaches the market (FAO, 2003). On the other hand, there are very limited researches that examine upstream or supply side of risks in agriculture (Ali and Kapoor, 2008).

Due to drastic changes in agricultural production environment, such as weather pattern, climate change, socio-economic and institutional changes; the producers find it difficult to respond and meet the expected demand. There are however, few studies that holistically examine risk across the agricultural supply chain. Of particular interest in the present study is 'upstream agricultural supply chain risks' which refers to risks associated with inbound processes of input supply, production, post harvest and marketing, and the subsequent impact on farmers (Figure 2.3).

Figure 2.3: Ishikawa diagram - supply chain risk categories and impacts



2.4 Sources of Agricultural Risks in India

2.4.1 Input Risks

Risk plays an important role in the investment decisions of farmers and input choices (Knight et al. 2003). The risk inherent in adoption to a new technology or input choices affects farmers differently depending on their attitudes towards risk and capacity to absorb the risks (Liu, 2008; Isik and Khanna 2003). Developing countries' farmers particularly small-scale and poor producers face considerable risks in their farm investment and input choices due to lack of timely availability, affordability, accessibility of modern inputs and farm technology (Ali and Nath, 2012). As crop production requires huge investments in farm inputs, any stress on availability of these inputs may disrupt the overall production system and supply chain. Ali (2008) based on survey of 642 fruits & vegetables growers in Uttar Pradesh (India), concluded that a majority of producers were stressed due to lack of timely and adequately availability of improved seeds, fertilizers and power supply. This ultimately affected the output and farm income. The adoption rate of new farm technology in developing countries is also very poor as compared to developed ones. According to 59th round NSSO report, in India, only 46% farm households adopted improved/HYVS, and 76% uses chemical fertilizers in Kharif season. The seed replacement rate is also very poor as only 30% households replace every year, 32% every alternate year, 21% after three year, and remaining 17% after four years or more. Furthermore, only 40% households have access to information on productive farm technologies that indicate towards poor extension services in the country. In addition, small-scale and poor farmers who are primary stakeholders in agriculture, find it more difficult to get modern inputs mainly due to lack of capital, collateral problem, high interest rate, and mounting input prices.

Lack of increase in the prices of agricultural products compare to agricultural inputs is one of the major causes of farmers' suicide in cotton-growing region Vidharbha (the eastern region of Maharashtra state, India) (Deshmukh, 2011). Monsanto's GM cotton seeds create a suicide economy by transforming seed from a renewable resource to a non-renewable input which must be bought every year at high prices. According to the National Crime Records Bureau (NCRB) data from 2010, more than 250,000 farmers have killed themselves since 1995. That is, two farmers a day for the past 15 years i.e. Every 12 hours one farmer commits suicide in India. Maharashtra,

Madhya Pradesh, Karnataka, and Andhra Pradesh are among the leading Indian states where farmer's suicide is very high.

2.4.2 Production Risks

Agriculture is often characterized by high variability of production outcomes due to several internal and external factors affecting the production process and yield. Production risks are associated with all events that make final production outcome uncertain when production decisions are taken. The production or yield risks arise due to biotic and abiotic factors in the short run, and potential climate changes, inefficient support infrastructure etc., in the long run. Major sources of production risks are weather, climate change, pests, diseases, the interaction of technology with other farm and management characteristics, genetics, machinery efficiency, and the quality of inputs (Skees et al., 2006).

2.4.2.1 Weather and Climate Change

Of all risk factors affecting agricultural production and especially crop production, weather is typically the most significant (Mirinda and Vedenov, 2001). Weather phenomena are hard to predict therefore is considered as a major source of uncertainty in agriculture. Weather is significant in every phase of agricultural activity from the prepatory tillage to harvesting and storage. Weather in its many attributes – rainfall, temperature, and sunlight - is an input into the production process. Climate change which refers to a change in the state of the climate is altering the frequency and severity of extreme weather and climate events such as droughts, wildfires, storms and floods affecting agriculture in a variety of ways (IPCC, 2012; Cline, 2008). Production and productivity of almost all crops depends on weather patterns in a particular area. Hence, any change in weather pattern due to increase in global temperature may affect productivity and, thereby threaten food security (Sushil and Nath, 2010). Besides, alterations in the soil moisture storage, pests and weeds, water availability and other such factors brought about by climate change may also affect productivity (Dasgupta and Sirohi, 2010; Kaur and Hundal, 2008; TERI, 2002). In semi-arid and arid areas, the length of growing seasons and the yield potential are expected to be decrease (Sivakumar and Stefanski, 2008). In Asian regions, researches have concluded a mix of possible impacts of climate change, in short term. It is projected that crop yields could increase up to 20% in East and Southeast Asia while they could decrease upto to 30%

in Central and South Asia, by the mid-21st century (Sivakumar and Stefanski, 2008). Thus, the climate change may increase regional disparities in food production.

In India, the impact of climate change as indicated in some simulation studies that a 2°C rise in temperature may reduce the potential yields of foodgrain (mainly wheat and rice) by about 15-17% in north India (Hundal and Kaur, 2007; Aggarwal and Sinha, 1993). Another study by Geethalakshmi and Dheebakaran (2008) resulted that temperature and precipitation changes may reduce the rice yields (during the kharif season) by 10-15 percent by 2020 in the state of Tamil Nadu. By 2050, the study projected to aggravate further 30-35% decline in the magnitude of yield. At the country level, a substantial decrease in wheat production is likely to occur if the existing pattern of climate change continues.

2.4.2.2 Pests and Crop Diseases

The effects of climate change on pests and pathogens have been evaluated in some experimental and modelling studies (Admassu et al., 2008; Garrett et al., 2006; Woods et al., 2005). Recent researches have resulted that global crop losses due to pests and insect estimated highest 10.8 percent while in developing countries this figure reaches upto 17.5 percent (Dhaliwal et al., 2010). In India, the annual average crop losses due to insect pests and diseases are estimated to be 18 percent of the agricultural output (Birthal, 2004). In particular to vegetables, it is estimated to be upto 30 percent of the total vegetable output (Alam, 2001). In term of monetary loss in India, pests and insects together causes an annual huge loss of Rs. 8,63,884 million (Dhaliwal et al., 2010).

2.4.2.3 Natural Disasters: Droughts , Floods and Tsunami

There is impact of extreme natural events such as droughts, floods, and tsunami which frequently accumulates into setbacks of development gains in poor and developing countries (Rao, 2010). Drought is the single most common cause of food shortages particularly in developing countries. In India, an agricultural drought is defined as a period of 4 consecutive weeks of (meteorological) drought in the period from middle of May to middle of October or 6 such consecutive weeks during the rest of the year (Ramaswami et al., 2003). On the other hand, the Indian Metcorological Department (IMD) is given a different definition based on rainfall deficiency. It defines drought as a situation when the deficiency of rainfall in an area is 25% or more of the normal. When the deficiency of rainfall is more than 50% of the normal, it is termed as severe drought Areas where the probability of drought is at least 20% of the time period are classifie

as drought areas while areas where probability of drought is at least 40% are chronic drought areas.

As per Government of India reports, about 68% of the country is prone to drought in varying degrees. Most of the drought-prone areas are found in arid, semi-arid, and sub-humid regions of the country, which experience less than average annual rainfall i.e.1200 mm (slightly more than the global mean of 990 mm).The most immediate consequence of drought is a fall in crop production, due to inadequate and poorly distributed rainfall (Toulmin, 1986). Drought was one of the major factors contributed to low and unstable rice production and affecting 20% of the total rice area in Asia (Pandey et al., 2007). In eastern India (Orissa), significant yield loss in rice production in major drought years was estimated by Pandey and Bhandari (2007). Low rainfall also causes poor pasture growth which may lead to a decline in fodder supplies from crop residues. The ultimate effect of a fall in crop production and fodder is to reduce the draft capacity of the farming sector, leading to lower crop output in the subsequent farming season. However, each drought event is unique in terms of drought intensity, impact on economy, and ability of individuals and society to cushion the losses (Markandya and Mysiak, 2010; EPA, 2008).

Floods are other dangerous events that are caused naturally by the overflow of the huge volume of water, from rivers, lakes, oceans, or by heavy rains. India, being a peninsular country and surrounded by the Arabian Sea, Indian Ocean and the Bay of Bengal, is quite prone to flood. As per the Geological Survey of India (GSI), the major flood prone areas of India cover almost 12.5% area of the country. Of the different natural hazards affecting large extent to the country' geographical location, flood is the most recurring, widespread, and disastrous (Kale, 2003, 2004). The number of people affected by flooding in India by hydrological disasters overwhelmingly exceeds that by meteorological, climatological, and geophysical disasters (Scheuren, 2008; OFDA/CRED). Crop damage is one of the worst damages caused in floods. Major flood prone areas in India are the river banks and deltas with major states like West Bengal, Orissa, Andhra Pradesh, Kerala, Assam, Bihar, Gujrat, Uttar Pradesh, Haryana and Punjab. In addition, agricultural production in many coastlines in the world is always at risk from tsunamis. The tsunami that struck South-east Asian countries in 2004 destroyed the agriculture as a whole in the affected coastal areas. In Tamil Nadu

(a coastal area province in India), as high as 30,000 hectares of cauvery delta area has turned saline, making the land unfit for cereal cropping (Jayashree, 2004).

More dangerous, the recurring tsunami hits coastal areas and affects lives & livelihood of coastal people. The tsunami that struck South-east Asian countries in 2004 destroyed the agriculture as a whole in the affected coastal areas. In Tamil Nadu (a coastal area province in India), as high as 30,000 hectares of cauvery delta area has turned saline, making the land unfit for cereal cropping (Jayashree, 2004).

2.4.3 Post-harvest Risks

Risk associated with post harvest crop losses in the processes of handing, storage, and transportation is of serious concern, impacting food security in developing and poor countries (Kumar and Nath, 2010). Post-harvest loss refers to both quality and/or quantity losses between the moments of crop harvest and its consumption. Crop losses occur at all stages of the post-harvest handling, including pre-processing, loading and unloading, transportation, storage, and packaging & marketing.

According to an estimate provided by Food Corporation of India (FCI) in reply to question posed by RTI activist Dev Ashish Bhattacharya, over 10 lakh tonnes of foodgrain was damaged/lost in the godowns of government owned agency which is responsible for procurement and distribution of foodgrains across the country. According to this estimates, about 1.83 lakh tonnes of wheat, 3.95 lakh tonnes of rice, 22 thousand tonnes of paddy and 110 tonnes of maize were damaged between 1997 and 2007. This amount of foodgrain could have fed over 10 million people in a year. The quantity of annual foodgrain damaged in India averaged at 0.58 lakh tonnes (Kumar and Nath, 2010). Ironically another 2.59 crore was spent just to dispose-off the rotten food grains (The Financial Express, November 7, 2010). Post-production losses are significantly high particularly in high perishable nature of crops like fruits and vegetables (Ali and Kapoor, 2008). Poor postharvest handling and lack of quality control practices compromise both the quality as well as increase the risk of food borne pathogen contamination. World-wide postharvest losses account for 10–50% of harvested vegetables - a significant waste (Schnitzler, 1998). In India, about 30% of the fruits and vegetables grown get wasted annually due to gaps in the cold chain (Maheshwar and Chanakwa, 2006).

Lack of sorting facilities, poor packaging, and unavailability of cold storages in close proximity to farms and poor processing & marketing infrastructure add to the deterioration of these perishables (Pulamte, 2008). This results in instability in prices, farmers not getting remunerative prices, rural impoverishment resulting in farmers' frustrations and suicides (Maheshwar and Chanakwa, 2006). Like other agricultural crops, high perishable horticultural products have a seasonal production cycle with abundant supply at harvest time. Local markets are thin to absorb production, and higher value products often justify the higher cost modes of transport in distant markets when timely delivery is paramount. Also, crop prices are volatile and usually at their lowest in harvest season and reaches peak when the surplus crop was sold by farmers.

2.4.4 Marketing and Price Risks

Market risk refers to uncertainties associated with prices of inputs and outputs. It also includes any other uncertainties from the markets such as the conditions imposed by the contractors, and logistics & supply chain difficulties, and risk associated with access to finance to support trading activities. Output price variability originates from both endogenous and exogenous market shocks (Shilpi and Umali-Deininger, 2007). Segmented agricultural markets will be influenced mainly by local supply and demand conditions, while more globally integrated markets will be significantly affected by international production dynamics. Price risk depends on extent of exposure to market forces as well as existing market institutions (Selvaraj and Ramasamy, 2006). Although production risks cause price risks, the latter is not just because of production risks alone. Prices can also vary because of demand shocks as well as instability in expectations formation. In particular, greater vertical and horizontal integration, higher and more stringent quality standards, new types of contractual arrangements and market institutions, result in a higher risk of market exclusion for smallholders (Mahendran et al., 2011). On the other hand, both smallholders and other actors in agricultural supply chains tend to face greater risks and transaction costs in dispersed chains than in more integrated ones (FAO, 1997).

The nature of agricultural market has significantly changed with pronounced volatility of international markets for agricultural commodities over the past few years appear to have intensified concerns about price risk among farmers (Tangermann, 2011). The balance of supply and demand determines crop prices. Variability in prices is therefore either due to variability in supply or demand or both (Ramaswami et al.,

2003). However, if the variability in either supply or demand is anticipated, so can be the resulting variability in prices. As a result, even if prices are variable, they are not risky for farmers as they are anticipated at the time of planting. According to Ramaswami et al. (2003), demand shock can be sizeable for industrial crops like cotton and jute as their demand is derived from the industrial sector which is subject to business cycles in industry. Whereas, supply shocks are because of production or yield risks (FAO, 2008). The impact of yield risks on prices depends on the elasticity of demand. A demand is said to be inelastic if an increase in price does not fall much in demand. On the other hand, demand will be elastic when an increase in price decreases demand considerably.

Generally, at the farmer level, price or market risk results from changes in prices of outputs or of inputs after a production decision has been taken (Dercon, 2002; Schade et al., 2002.). The price changes may result from different sources such as variability in supply and demand on domestic and world markets, change in agricultural policy and change of consumer behaviour (Heidelbach et al., 2004). Excessive volatility of input and output prices makes it more difficult for farmers to undertake long-term planning (EC, 2011). Over the years, input costs have, on average, increased more than output prices, leaving farmers with a 'squeezed' margin between revenues and input costs. In developing countries like India, the producer gets the lowest price and the ultimate consumer pays the highest as the involvement of more middlemen in the entire distribution process who keep the margins and move the produce further (Barnett et al., 2005). As it is well known more the number of mediatory more will be the costs as each transaction incurs expenses and invites profits. Eventually, when it comes to the producer the cost of the produce goes up steep (Fuentes, 1998). Further, with the growing commercialisation of agriculture, the magnitude of shock due to unfavourable eventualities is increasing and the need to protect farmers against production and income losses is becoming stronger (Satyasai and Viswanathan, 1997).

Price risk is the risk of price decrease or increase after a production modification has been made (OECD, 2009). Price volatility increases income uncertainty (Läänemets1, 2011). In integrated markets, a reduction in prices is generally not correlated with local supply conditions and therefore price shocks may affect producers in a more significant way. Another kind of market risk arises in the process of delivering production to the marketplace (Pokhrel and Thapa (2007). The inability to

deliver perishable products to the right market at the right time can impair the efforts of producers. The lack of infrastructure and well-developed markets make this a significant source of risk.

For agricultural commodities which can be stored such as wheat, rice, pulses and coarse cereals, stock changes may dampen the price fluctuations. Stakeholders stock the commodities when price is low, expecting to be able to sell later at a higher price, as a result covering the cost of stockholding and making a profit. This additional demand from stockholders dampens the price decline. In contrast, at high prices stocks are run down, so providing additional supplies that moderate the price increase. However, once stocks are run down they can no longer contribute to dampening the price increase. Wright (2009) explained that the fluctuations in market prices of storable agricultural commodities, hence, exhibit a typical asymmetric attribute, where frequent fluctuations around the average are interrupted by occasional sharp upward price spikes but not equally pronounced downward troughs.

Table 2.4: Sources of risk in agriculture and agricultural supply chain

Risk Categories	Sub-categories of risk	References
Input Risk	Lack of availability and accessibility & adoption of critical inputs, poor quality, lack of capital, lack of collateral, high interest rate on loans, Increase input prices.	Vaswani (2011), Ali and Kapoor (2008), Ibitayo (2006),Hardaker (2000), Lapan et al. (1991).
Production Risk	Weather uncertainties, climate changes, insufficient/delayed rainfall, fallen underground water, inefficient support infrastructure, lack of irrigation facilities, diseases including non-contagious diseases, termites attack/insects, pests, lack of technical skills/GAP, over-cultivation, personal hazards (illness, death), family conflict & violence, lack of reliable labour/expensive labour/high labour migration, genetics, traditional farming methods, frost, hail/tempest, flood, drought, assets risk.	Gregory et al. (2009), Baez et al. (2009), Raju and Chand (2008), Ali and Kapoor (2008), Rao (2008), Lourdes and Felino (2007), Barnett and Mahul (2007), Barnett (2005), Pingali (2001), FAO (2001), Haggerty (2001), Turvey (2001),Huirne et al. (2000).
Post-harvest Risk	Perishability, poor handling, lack/poor packaging, lack of sorting/grading, lack of processing techniques, lack/poor transportation facilities, lack/poor storage facility/cold chain, lack/poor quality control practices, post harvest losses.	FAO (2011), Kumar et a. (2011), Ali and Kapoor (2008), Basavaraja et al. (2007), Rajagopal (2002), Raghavan (2002), Deshpande and Singh (2001), Nag et al. (2000).
Marketing & Price Risk	Inaccessibility of market/lack of market linkages, infrastructural bottlenecks, high marketing costs, variability in input / output prices, changes in trade policy/marketing regulations, lack of market information, exploitation by middlemen, lack of discriminatory pricing for quality/graded produce, low economies of scale & bargaining power, new markets.	Vaswani (2011), OECD (2009), Ali and Kapoor (2008), Shilpi and Umali-Deininger (2007), Pokhrel and Thapa (2007), Fafchamps and Hill (2005), Hardaker et al. (2004), Chambers and Quiggin (2003), Holzmann and Jorgersen (2001), Binswanger and Rozensweig (1993), Holthausen (1979).

The multiplicity and diverse sources of risks make farming decisions more complex to tackle, and pushes the producers into the vicious cycle of low livelihood. Furthermore, the types and sources of risks are interrelated in nature, which a serious methodological limitation in designing risk management strategies.

2.5 Review of Risk Management Approaches / Strategies in Agriculture

Risk is an integral part of agriculture. Over the past few decades, the agricultural risk environment is changing fast with increasing frequency, scale, intensity, and duration of agricultural risks of all sorts. In order to manage agricultural risk, it is essential to recognize the extent likelihood and consequences of the risk (Norrman and Lindroth, 2004). There are growing number of literatures on quantifying and managing risks in agriculture, particularly from developing countries in light of the need to improve agricultural production to meet the food security, poverty reduction and providing industrial raw materials (Kumar and Nath, 2010, Ali and Kapoor, 2008). Ali and Kapoor (2008) emphasised the need for better understanding of cross-cutting issues and multiple approaches to managing agricultural risk. Risk management has also become a major policy issue in recent and on-going agriculture policy reforms in many developing countries including India.

Suhaiza and Nyoman (2009) pointed out that although supply chain management has always had a strong emphasis on risk, the notion of supply chain risk management has gained momentum in recent years due to increasing supply chain complexity. Risks can be seen as relating to the probability of uncertain future events which have a devastating impact on each stage on the supply chain. Therefore, objective of risk management is to decrease the probability and impact of adverse events. On the other hand, any event that could have a positive impact should be exploited (Gardiner, 2005). According to Gray and Larson (2008) risk management is a proactive approach rather than reactive approach. Risk management approaches in agriculture can be distinguished according to whether they are undertaken before (ex ante) or after an event (ex post) (World Bank, 2005).

Ex-ante strategies are designed to avoid the risk from occurring (risk prevention), or, if this is not possible, to reduce its impact (risk mitigation) or limit

exposure to risk (Hoogeveen et al., 2005). Among the ex ante reactions, it can also be important to highlight the differences between on-farm strategies and risk-sharing strategies in order to design risk management strategies (Anderson 2001). Ex-post risk coping strategies are designed to relieve the impact of the risk once it has occurred. Various formal and informal mechanisms are available to manage agricultural risk for both ex ant and ex post periods. According to World Development Report (2001) informal strategies are identified as "arrangements that involve individuals or households or such groups as communities or villages," while formal arrangements are "market-based activities and publicly provided mechanisms."

Risk response strategies as recommended by various literature including the six sigma body of knowledge may include avoidance, reduce, pool, transfer or acceptance of risk (USDA, 2009; Hillman, 2006; Sheffi, 2005; Rudi, 2001; Johnson, 2001). An effective risk management relies on an optimal combination of technical and financial tools (Iturrioz, 2009). The strategies used by farmers to address the financial consequences of risk generally can be categorized as risk mitigation, risk transfer, risk diversification, and management of retained risk (Ibarra and Skees, 2007).

Mitigation refers to actions that alter the chances of an event occurring. For example, irrigation and pest management are widely used risk mitigation mechanism by farmers that reduce either or both the probability of a loss occurring and the severity resulting from a loss event. Shifting risk from one to another party by means of insurance and futures markets are famous market based risk transfer mechanisms. Risk diversification which refers to a production mix or mix of activities is very common mechanism to diminish the impact of risk on producers' welfare (Ali and Nath, 2008). Apart from these, producers also retain some degree of risk exposure and use additional strategies for smoothing consumption across time.

According to Jaffee et al (2010), each strategy for managing risk can be carried out through a variety of instruments, each with different private and public costs and benefits, which might either increase or decrease the vulnerability of individual participants and the supply chain (Ali and Kapoor, 2008; Miller et. al, 2004; Clark, and Brinkley, 2001). When selecting a mix of risk responses, it is essential to consider the many links between risk management strategies and instruments (World Bank, 2011).

2.5.1 Ex-ante Strategies

2.5.1.1 Informal Mechanisms

Ex ante informal strategies rely on two main approaches: risk prevention and risk reduction or risk mitigation. A farmer can also simply avoid risk, as extreme poverty make them very risk averse, often avoiding activities that entail risk but that could also bring larger income gains (Ritchie and Brindley, 2007). This inability to manage risk and accumulate and retain wealth is sometimes referred to as the "the poverty trap" (World Bank 2001). Risk reduction strategies may include diversification of income sources (such as such as through off-farm employment and migration); and choice of agricultural production strategy through investments in hazard-resistant technology (such as irrigation systems and pest-resistant seed varieties) (World Bank, 2005).

Rosenzweig and Stark (1989) reported that farm households with more farm profit volatility are more likely to have a family member engaged in steady wage employment. Buffer stock accumulation of crops or liquid assets, and the use of credit present obvious means for households to smooth consumption (World Bank, 2005). The households with substances consumption prefer to plant traditional varieties of crops than to riskier, high-yielding varieties (HYVs) (Morduch, 1995). Crop-sharing arrangements in land renting, sharing agricultural equipments including irrigation sources can also provide an effective way of sharing risks between individuals, thus reducing producer risk exposure (Hazell, 1992; Balcombe, 2009; Székely and Pálinkás, 2009). Also, community-level risk pooling occurs in specific communities where members of the group transfer resources among themselves in order to rebalance marginal utilities (World Bank 2001).

2.5.1.2 Formal Mechanisms

Agriculture has always been considered by Government as strategic sector particularly in developing countries, given that food as a basic requirement (Raju and Chand, 2007). Various initiatives have been taken by Government through various programmes and schemes in order to provide succour to farmers facing the adversity. Various market based mechanisms are also available to farmers in order to manage their agricultural risks. FAO has classified the comprehensive agriculture risk management framework into three categories.

1. Direct initiatives on the part of the Government, such as rural infrastructures development (roads, dams, irrigation systems), farm management advice, supply of quality inputs, agricultural extension services and farm training.

2. Indirect initiatives on the part of the Government to mitigate production risks through insurance mechanisms covering crops, weather and livestock and including micro insurance.

3. Market-based approaches to mitigate price or income risks, which include farm income insurance, commodity markets, contract farming, etc.

2.5.1.2.1 Direct Government Interventions: Rural Infrastructure Development

Agriculture Infrastructure is the essential input for agricultural development and poverty alleviation (Venkatachalam, 2003; Ghosh, 2006). As three to four percentage points of GDP in infrastructure investment, reduces poverty by 0.6 to 1 % annually (NABARD, 2010; Besley & Burgess 2003).

Fosu et al. (1995) listed 12 components under the agricultural infrastructure services which are: irrigation and public access to water, means of transportation, storage services, commercial infrastructure, processing infrastructure, public services, agricultural research and extension services, communication and information services, biotechnology, land conservation services, credit and financial institutions, and finally, health and education services. Covering to these, some of the major schemes are being implemented by Govt. of India in this regard such as Development and Strengthening of Infrastructure Facilities for Production and Distribution of Quality Seeds; National Mission on Micro Irrigation; Development/ Strengthening of Agricultural Marketing Infrastructure, Grading & Standardisation; Gramin Bhandaran Yojana; and Rashtriya Krishi Vikas Yojana. Further, recognising the conscious need for creation of basic infrastructure to support agriculture, the Rural Infrastructure Development Fund (RIDF) was set up in NABARD in 1995-96 in order to strengthening rural infrastructure with major focus on rural roads and bridges, irrigation, post-harvesting facilities, marketing infrastructure etc. This has resulted in improved productivity/efficiency, reduced production costs, and post-harvest losses, which further enhance income and employment for the farming community in the intervene regions.

NABARD (2010) in a RIDF evaluation study conducted in Maharashtra found that, due to improvement in transport and marketing infrastructures, farmers' access to market especially with reduced distance has induced changes in cropping pattern towards cash crops with higher yield. Further, the average reported saving in wastage was found 2.97 % of the marked surplus and the 20% the farmers have even changed their market places too to realize higher prices. The evaluation study in Uttar Pradesh reported average price gain of 2.2% and reduction in input price too at the farm gate. Likewise, economic rate of return (ERR) in irrigation projects varied from the minimum 16 % for a minor in Haryana to 149 % for a deep tube well in Gorakhpur, depending upon pre development situations of the area.

Rural roads and bridges open opportunities for new entrepreneurial activities that may include more dairy farming and fruits & vegetables shops due to linkage with outside consumers, purchase tractors, passenger and transport vehicles by the villagers, wage/ trade opportunities outside the village. The economic rate of return (ERR) in roads and bridges project, it varied from 5% for road in Gorakhpur to 69% for a bridge in Orissa (NABARD, 2010). The other schemes like Mahatma Gandhi NREGA and Pradhan Mantri Gram Sadak Yojana (PMGSY) are also playing crucial role in improving the rural infrastructures development (Ministry of Rural Development, Govt. of India 2010). Furthermore, the Govt. established Biotech Parks which also plying vital role in raising the crop productivity through the application of biotechnology in agriculture like tissue culture, terminator gene technology and genetic cloning.

However, there is a wide disparity in agricultural growth between different regions within country (FAO, 2008). Explaing to this, Venkatachalam (2003) pointed out that since the responsibility of providing infrastructure is with the state which aims at rapid growth of agricultural production for attaining other kinds of developmental goals such as poverty alleviation, there exists a tendency among the decision-makers to invest heavily in those areas where there is a potential for fast agricultural growth.

2.5.1.2.2 Indirect Government Interventions: Crop/ Weather Insurance

Though agriculture risk management is a relatively new field in developing countries, there has been a surge of interest in new market-based and traditional risk management instruments and approaches in recent years (Ghatak and Pandey, 2000). Agricultural

Insurance is a means of protecting the farmers against financial losses due to uncertainties in agricultural production (AIC. 2008). Crop insurance which is a risk-transfer mechanism also facilitates adoption of improved technologies, encourages higher investment resulting in higher agricultural production (Ibarra and Skees, 2007). Based on peril coverage, the agricultural insurance can be broadly categorized into two categories: single (offers protection from single hazard) and multi-peril coverage (protection from several hazards). In India, multi-peril crop insurance programme is being implemented, considering the overwhelming impact of nature on agricultural output and its disastrous consequences on the society, in general, and poor & small farmers, in particular (Raju and Chand, 2007).

The Comprehensive Crop Insurance Scheme (CCIS) which was in operation in the country since 1985 has been replaced by National Agricultural Insurance Scheme (NAIS) which was introduced from the rabi season of 1999-2000. The broader objectives of NAIS are to protect the farmers from crop failure on account of natural calamities, such as, flood, drought, hailstorm, cyclone, fire, pest/diseases etc. so as to restore their credit worthiness for the ensuing season. The scheme is operating on the basis of both 'area approach', for widespread calamities, and 'individual approach', for localized calamities such as hailstorm and landslide. It envisages coverage of all food crops (cereals, millets and pulses), oilseeds and annual horticultural /commercial crops, in respect of which past yield data is available for adequate number of years. At present this scheme is being implemented in 25 States and 2 Union Territories (UTs) with an average performance. According to ministry of Finance (Govt of India), since inception of the scheme to March 2011 about 176 million farmers have been insured, covering an area of 269 million hectares for a sum insured value of Rs. 2,21,213 crore, against a premium of Rs. 6589 crore. Claims to the tune of about Rs. 22190 crore have been reported so far benefiting nearly 47.6 million farmers representing a claim ratio of 1:3.37. Due to some limitations, the NAIS has been revisited as modified NAIS (MNAIS) has been formulated, incorporating the necessary changes /modifications in consultation with states to remove the deficiencies and make it more comprehensive and farmer friendly.

Considering the high variability and uncertainties in weather, Weather based Crop Insurance Scheme (WBCIS) was launched in the country in Kharif season in 2007, aims to mitigate the hardship of the farmers from incidence of adverse conditions

of weather parameters such as deficit and excess rainfall, high or low temperature, frost, humidity etc. which are deemed to impact adversely the crop production. It has the advantage of settling the claims within shortest possible time. According to press Information Bureau Govt. of India, the coverage of farmers under WBCIS has gone up from 35 thousand in Kharif 2007 to 61.6 lakh in Kharif 2011. Claims worth Rs. 972 crore have been settled so far. The overall coverage under the scheme is 1.95 crore farmers over an area of 2.78 crore hectares.

In spite of various insurance schemes and programmes, in many developing countries including India, broad-based formal insurance markets are hindered by problems of imperfect information and costly enforcement (Rao, 2010). According to National Agriculture Policy India (2000), despite technological and economic advancements, the condition of farmers continues to be unstable due to natural calamities and price fluctuations. Raju and Chand (2007) found these unfavourable events as one of the factors leading to farmers' suicides which are now assuming serious proportions.

Innovation plays important role in risk management and sustainable agricultural development (Leeuwis et al., 2006). Particularly, financial innovations in farming system are essential to reduce transaction costs and managing risk and so strengthening agricultural supply chain through the favorable impact on saving, investment and output (Nath, 2009). Appropriate use of technology seems an important way to improve agricultural production and to dramatically reduce transaction costs. As a pioneering credit delivery innovation in India, Kisan Credit Card scheme was launched in 1998-99, aims at providing adequate and timely credit support from the banking system to the farmers for their cultivation needs including purchase of inputs in a flexible, hassle free and cost effective manner. Coverage of Crop Loans disbursed under KCC under the Rashtriya Krishi Bima Yojna (RKBY) provides insurance coverage and financial support to the KCC holders in the event of failure of crops as a result of natural calamities, pests and diseases. The KCC holders are also covered under the Personal Accident Insurance Scheme (PAIS) up to Rs.50,000, in case of death or permanent disability resulting from accidents caused by external, violent and visible means. In such cases, the premium expenses are also shared by the KCC holders, PACS and the CCB in the ratio 50:25:25 respectively (in specific to the state of Orrisa). According to

Ministry of Agriculture, Govt of India, in the year 2009-10, more than 90 lakhs cards (KCC) issued to farmers which amounted a total sum of Rs. 57678 crore.

2.5.1.2.3 Market-based Approaches to Mitigate Price Risks

The price risk refers to the probability of adverse movements in prices of agricultural products and commodities. Agriculture is a seasonal activity. Therefore, most of the agricultural produce arrives in the market immediately after its harvest. As a consequence, commodity prices sink during the harvest time to their lowest level and start rising after that till the next harvest (Skees, 2001). Unfortunately, farmers particularly in developing countries do not have the ability to store their produce and wait for prices to become more favourable. Similarly, during the harvest, prices are relatively higher at places farther away from the fields (Ali and Nath, 2008). However, the farmer does not have the capacity to transport his produce to such locations and take advantage of the higher prices.

One way farmers have traditionally managed price variability is by entering into pre-harvest agreements that set a specific price for future delivery through forward contracts (World Bank, 2005). The forward and futures contracts are efficient risk management tools which insulate buyers and sellers from unexpected changes in future price movements (Lien and Quirk, 2002). While forward contracts are mainly over-the-counter and tailor-made which are settled by physical delivery, futures are standardized contracts whose transactions are made in formal exchanges through clearing houses and generally closed out before delivery (Sahadevan, 2002). Futures contracts are an improved variant of forward contracts. These contracts enable them to lock in the prices of the products well in advance.

Futures market is a boon to the farmers. Even though farmers may not be directly participating in large numbers in the futures markets, the benefit of transparency in futures platform as regards price discovery accrues to them (Ali and Gupta, 2011). It gives farmers advance information and indications at the time of sowing, the price that can be expected at the time of the harvest and demand & supply conditions of the commodity traded (Lien and Quirk, 2002; Sahadevan, 2002).

In India, the agricultural farm holdings are dominated by small and marginal farmer where farming is often done on subsistence basis (Pasha, 1991). So, whatever benefits the farmers derive are likely to be indirect. Direct participation of farmers in

commodity futures is something that does not occur even in developed countries like the US with over 100-year-old commodity futures markets and large farm holdings. There are strategies developed to bring farmers through aggregation (for instance HAFED hedged wheat on NCDEX platform). This kind of aggregation needs to be carried out on larger scale to bring in the farmers. Importantly, for commodity derivatives market to work efficiently, it is also necessary to have a sophisticated, cost-effective, reliable and convenient warehousing system in the country. However, unfortunately it is scarcely recognized by those who represent the farmer's interests that futures market does not benefit directly to farmers and instead to traders who have the money power and networking capabilities. As the counterpart of the farmer, who would like to take advantage of higher prices in future or at a different place, there are consumers, traders, processors who would like to take delivery of the produce at a future date or at another place rather than on the spot and at the time of the harvest.

Contract farming offers another approach to market/price risk management particularly for small scale producers in developing countries. Contract farming is a partnership between agribusiness/marketing firms and farmers, and has both advantages and disadvantages to both the parties Birthal et al. (2005). Basically, involvement of four things is necessary for working of such contracts (a) pre-agreed price; (b) quality; (c) quantity (which can be in the forms of minimum and maximum acreage) and (d) time of delivery (Singh, 2002; Dhillon and Singh, 2006; Pari, 2000). For small-scale farmers, contract farming serves as an assured market for their produce at farm gate, reducing marketing and transaction costs and also price risk (Eaton and Shepherd, 2001). Furthermore, in circumstances when farmers face problems in accessing inputs, technology, information and services, firms provide these as a part of contract and hence reduce uncertainty in their availability, quality and prices for the farmers (Rangi and Sidhu, 2000). Contract farming is often practiced in high-value perishable commodities that are riskier than other crops (World Bank, 2005). Contract farming for foreign contractors that is popular in Indian states such as Punjab and Gujarat is now making inroads in Maharashtra too. There are a good number of in depth studies available in the literature on contract farming in the context of India. Pepsi's contract farming initiative in India has been a success despite the country not having any contract farming policy.

A survey carried out by Nielsen in 2008 affirms that contract farming with PepsiCo has enhanced yield and farmers' incomes in the state of Punjab and helped reduce indebtedness. The report indicated that a majority of the PepsiCo farmers (96.4%) who had taken loans were of the opinion that contract farming with PepsiCo had helped reduce their debt. This is also due to the fact that 94 percent of the farmers felt the risk due to crop failure had reduced after adopting contract farming. PepsiCo has also developed a tractor-driven direct seeding machine which places the seeds at specified distance and depth and also applies fertiliser (Business Standards, June 11, 2010). However, farmer, being a weaker partner, is also prone to exploitation by the firm (Shoja, 2009). Other controversies including over-exploitation of land, tendency towards monoculture, market dependence, asymmetry about sharing gains between firm and farmers (Erappa, 2006)

2.5.2 Ex-post Strategies

2.5.2.1 Informal Mechanisms

If risk prevention and mitigation do not work, or not completely it leaves farm households with the residual option of coping with the shock once it occurs (ex-post). There are various ex-post informal mechanisms to compensate for shortfalls in farm income: sell stored farm produce, liquidate assets, deferred social & family functions, receive transfers from relatives, off-farm woks and migrate to cities in search of work (Rosenzweig and Wolpin 1993). Semi-arid rural households in developing countries like India generate income from multiple sources which may includes livestock income, off-farm seasonal labour, and sale of handicrafts (Walker and Ryan, 1990).

Gadgil et al. (2002) found that southern Indian farmers are able to quickly shift from on-farm labor activities to largely off-farm activities if the monsoon rains are expected to be poor or drought. In the mango growing Malihabad region in Uttar Pradesh (India), the mango growers generally avoid social and family functions in the non-crop years. Shift of correlated risk and risk sharing with households or institutions from areas largely uncorrelated with the local risk conditions through credit and transfer with distant relatives (Rosenzweig 1988; Miller and Paulson 2000); through migration and marriages (Rosenzweig and Stark 1989); or through ethnic networks (Deaton and Grimard 1992) are well known informal mechanisms in developing world.

2.5.2.2 Formal Mechanisms

Ex-post risk-related formal measures to reduce the impacts of risk involves development of relevant infrastructure and adopting social schemes and cash transfers for relief aftershocks have occurred (Rees, 2008; Kleindorfer, 2008). Governments sometime forgive debts or provide formal safety nets such as subsidies, rural public works programs, and food aid to help farms (and their labourers) to cope with negative impacts of risky events.

India subsidizes agricultural inputs in an attempt to keep farm costs low and production high. Govt. of India pays fertilizer producers directly in exchange for the companies selling fertilizer at lower than market prices. On the other hand, Irrigation and electricity are supplied directly to farmers by Govt. at prices that are below the cost of production. The agricultural policies result in effective subsidies to the farmer of 40 to 75 percent for fertilizer and 70 to 90 percent for irrigation and electricity. Further, there is a sharp increase in India's expenditure on input subsidies was recorded in recent years. According to Ministry of Chemicals & Fertilizers; and Central Electricity Regulatory Commission, the cost of India's agricultural input subsidies as a share of agriculture output almost doubled from 6.0 percent in 2003-042 to 11.6 percent in 2009-10, driven mostly by large increases in the subsidies to fertilizer and electricity. Even, India's agricultural sector is more dependent on input subsidies than that of the other large emerging economies. According to Ministry of Finance, Government of India, in calendar year 2007, India's input subsidies were equal to 9.6 percent of the value of its total agricultural output compared to less than 5 percent for Brazil, Russia, and China.

In case of disastrous impact, waiver of crop loans and rehabilitation packages are also provided in the affected areas and farmers. Recently, the government has announced a package of Rs. 2,000 crore to the farmers of cotton, soya, and paddy in the regions of Vidarbha, Marathwada and Khandesh (all in Maharashtra).

A summary of literature on approaches and mechanisms of risk management in agriculture supply chain management is presented in Table 2.5.

Table 2.5: Approaches and mechanism to risk management in agriculture

		Informal mechanism	*Formal mechanism*		**References**
			Market based	*Publically provided*	
Ex-ante Strategies	*On-farm*	• Avoiding exposure to risk • Crop diversification • Intercropping • Buffer stock accumulation of crops • Liquid assets • Low risk and low return cropping patterns • Investment in farm machinery/equipments • Adoption of new production techniques (fertilization, irrigation, resistant varieties) • Improved information system		• Agricultural extension & training • Pest management systems • Farm management advice • R & D programme • Infrastructures (roads, dams, irrigation systems) • Supply of quality inputs (seed, fertilizers etc.)	Meuwissen, Huirne and Alexander and Marshall (2006), Jaffee et al. (2008), Allen and Schuster (2004), Glauber (2004), Skees (1999), Alexander and Marshall (2006), Anderson (2001); Townsend (2005); World Bank (2001), Alizadeh and Nomikos (2005), Balcombe (2009), Székely and Pálinkás (2009), Ritchie and Brindley (2007), Acharya (2006)
	Sharing-risk with others	• Sharing food crop • Sharing agricultural equipments/irrigation sources • Informal risk pool	• Contract marketing • Futures & forward markets • Insurance • Use of ICTs		
Ex-post Strategies	*Risk Coping*	• Selling assets • Seeking temporary employment • Migration to cities • Reduced consumption • Deferred/low social & family functions • Borrowing from relatives • Spread sales • Diversified finance • Off-farm work	• Credit	• Subsidies • Credit • Waiver (cancellation) of crop loans • Rural works programs • Food aid • Social assistance & social funds • Cash transfer	Jaffee et al. (2008), Anderson 2001; World Bank 2001, Townsend 2005; Völker (2011), Walker (2008), Glauber (2004), Ali and Kapoor (2008), Miller et al. (2004)

2.6 Review of Methods, Tools and Techniques for Identification, Analysis and Evaluation of Risk

There were various methods/ tools and techniques adopted by different researchers in order to identify, analyse and evaluate the risk (Barnett and Mahul, 2007; Lourdes and Felino, 2007; Pokhrel and Thapa, 2007; Fafchamps and Hill, 2005; Pingali, 2001; FAO, 2001; Rozensweig; 1993). Considering the nature and scope of the study, the methods/ tools/ techniques can be classified into two major categories as Look-up/ Supportive methods and statistical methods (International Electrotechnical Commission, 2009). Most of the methods/ techniques/ tools have their own limitations in terms of risk identification, analysis and evaluation. An evaluation of all the methods and tools/ techniques in terms of its applicability for risk identification, analysis and evaluation is presented in Table 2.6. This evaluation may be helpful to choose the right methods/ tools/ techniques for the identification, analysis and measurement of risk for effective risk management.

Table 2.6: Applicability of methods/ tools/techniques used for identification, analysis and evaluation of risk

Methods/Tools/ Techniques	**Description**	**Risk Identification**	**Risk Analysis**			**Risk Evaluation**
			Consequence Analysis	Probability Estimation	Estimation the level of risk	
Look-up / Supporting Methods						
Brainstorming	Brainstorming involves stimulating and encouraging free-flowing conversation amongst a group of knowledgeable people to identify potential failure modes and associated hazards, risks, criteria for decisions and/or options for treatment.	SA	NA	NA	NA	NA
Delphi Technique	A means of combining expert opinions that may support the source and influence identification, probability and consequence estimation and risk evaluation. It is a collaborative technique for building consensus among experts. Involving independent analysis and voting by experts.	SA	NA	NA	NA	NA
Structured/Semi-structured Interview	In a structured interview, individual interviewees are asked a set of prepared questions from a prompting sheet which encourages the interviewee to view a situation from a different perspective and thus identify risks from that perspective. A semi-structured interview is similar, but allows more freedom for a conversation to explore issues which arise.	SA	NA	NA	NA	NA

Check-lists	A simple form of risk identification. A technique which provides a listing of typical uncertainties which need to be considered.	SA	NA	NA	NA	NA
Structure « What if? » (SWIFT)	A system for prompting a team to identify risks. Normally used within a facilitated workshop. Generally linked to a risk analysis and evaluation technique	SA	SA	SA	SA	SA
Root Cause Analysis	A single loss that has occurred is analysed in order to understand contributory causes and how the system or process can be improved to avoid such future losses. The analysis considers what controls were in place at the time the loss occurred and how controls might be improved.	NA	SA	SA	SA	SA
Decision Tree	A decision tree represents decision alternatives and outcomes in a sequential manner which takes account of uncertain outcomes.	NA	SA	A	A	NA
Cause-and-effect Analysis (fishbone diagramme)	An effect can have a number of contributory factors which may be rouped into different categories. Contributory factors are identified often through brainstorming and displayed in a tree structure or fishbone diagram.	SA	SA	NA	NA	NA
Scenario Analysis	Possible future scenarios are identified through imagination or extrapolation from the present and different risks considered assuming each of these scenarios might occur. This can be done formally or informally qualitatively or quantitatively	SA	SA	A	A	A
Statistical Methods						
Standard Deviation	A statistical measure of dispersion around a central tendency. Standard deviation measures volatility. It is an absolute measure of risk	NA	NA	NA	A	A
Skewness	Skewness asymmetry of a distribution in terms of risk, in other words is there a tendency for the data to be positive or negative.	NA	NA	NA	A	A
Coefficient of Variation (CV)	Coefficient of variation is the measure of variability of the data. When the value of CV is higher, it means that the data has high variability and less stability. When the value of CV is lower, it means the data has less variability and high stability. It is a relative measure of risk.	NA	NA	NA	A	A
Risk Matrix	A Risk Matrix is a matrix that is used during Risk Assessment to define the various levels of risk as the product of the harm probability categories and harm severity categories. This is a simple mechanism to increase visibility of risks and assist management decision making.	SA	SA	SA	SA	SA
Failure Mode Effect Analysis	FMEA is an advanced method of risk management that examines potential product or process failures/risks, evaluates risk priorities, and helps determine remedial/control actions to avoid identified potential failures/risks.	SA	SA	SA	SA	SA

SA: Strongly Applicable A: Applicable NA: Not Applicable

The literature review confirms that a number of methods/ tools/ techniques have been used in various research studies for analysing agricultural risks. The review summarized and classified all the sources of agricultural risk according to their origin at the supply chain stage viz. input risk, production risk, post-harvest risk and marketing & price risk. To address the risks, arrays of formal and informal risk management/ coping mechanisms were developed by the farming community and Government in the forms of direct and indirect interventions including market based approaches. However, these initiatives are often neither efficient nor sufficient and have not changed agricultural risk environment in the country. Also, the traditional risk management process is highly fragmented, ad-hoc, non-continuous and narrow focused which does not integrate small-scale farmers in the supply chain. There is lack of integrated and systematic approach to manage the emerging risks in agricultural supply chain. The existing literatures are lack in the use of advanced methods of risk measurement for effective risk management. These research gaps necessitated to undertake this study.

Chapter 3

CONCEPTUAL FRAMEWORK AND RESEARCH HYPOTHESES

This chapter introduces the conceptual framework for integrated supply chain risk management in agriculture and discusses hypotheses predicting the relationship and effect of clustering approach and socio-economic factors on managing potential risks. This chapter sets the stage which guided this research study.

3.1 Conceptual Framework for Integrated Supply Chain Risk Management

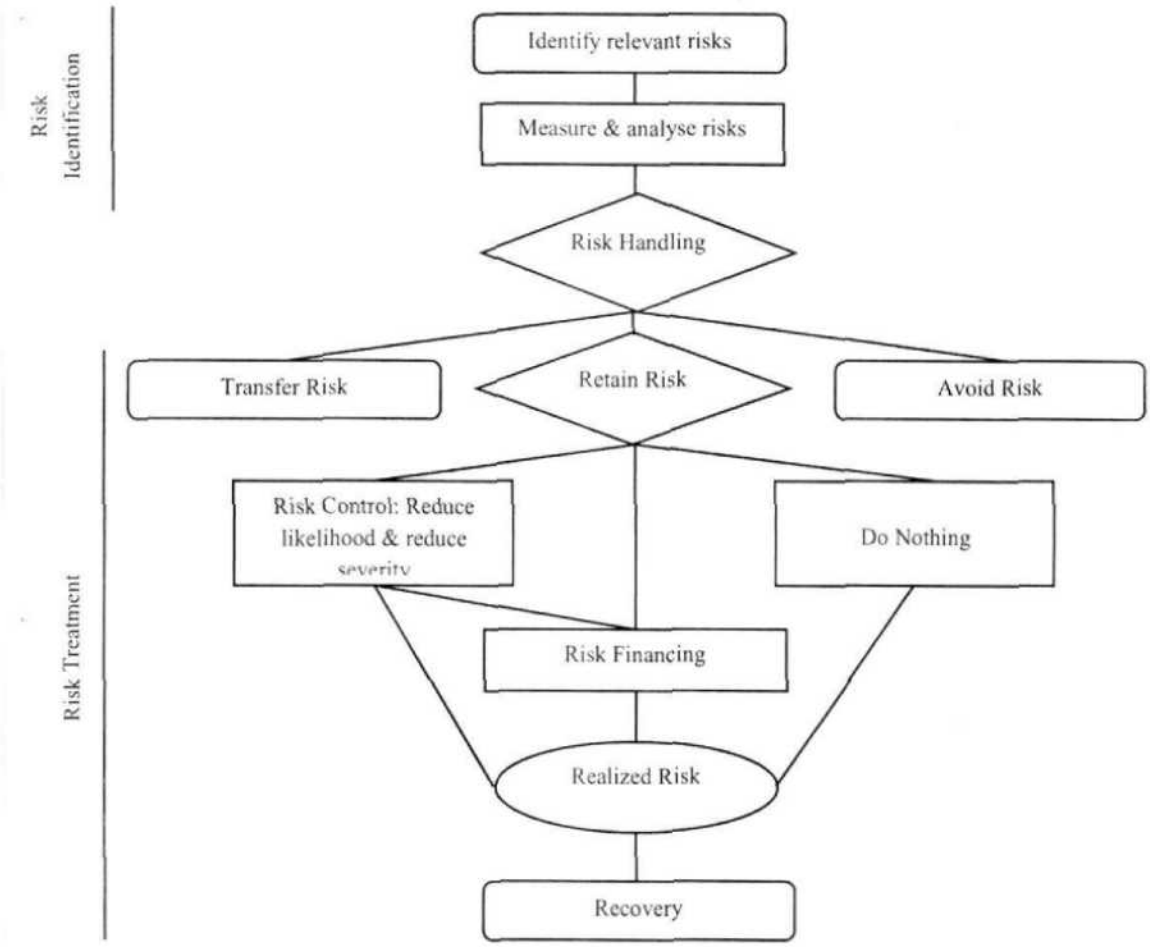
Based on a rigorous literature review it was found that a large number of studies on the various aspects of agricultural risk management have been conducted across the globe. To set up a holistic and integrated framework for systematic risk management in agricultural supply chain, it is of immense important to understand and then integrate the risk management processes, innovative risk management approaches and risk perception of the stakeholders across the chain.

3.1.1 Risk Management Process

Risk management do not preclude adverse events from occurring; however, it enables to focus on those things that are likely to bring the greatest harm, and employ approaches that are likely to mitigate or prevent those incidents (Tsohou et al., 2006; Gaudenzi and Borghesi, 2006).Risk management process consists of systematic steps of identification, assessment, control, monitoring & review, and communication of risk (Richard et al., 2008; Ojala and Hallikas, 2006; Sheffi and Rice, 2005; Finch, 2004). Broadly, risk management comprises of two stages (Figure 3.1.1). In the primary stage, risks are identified and characterized and then in the treatment stage, they are dealt with.

Figure: 3.1.1: Risk management process

(Rounded boxes are entry and exit points into the risk management process. Rectangles, diamonds, and ovals denote actions, decisions and chance events respectively)



Source: Adopted from Sethi (2010)

The risk identification process involves standardize the description and change in risk parameters which can be observed through risk analysis (Rao et al., 2005; Wu et al., 2006; Liangyuan and Yueheng, 2001). The appraisal and analysis of risk exposure involves the quantification of likelihood of occurrence and the consequences of potential future events (Wu et al., 2006; Zsidisin et al., 2004; Pich et al., 2002). The subsequent process involves the assessment and evaluation of risk for prioritization and identification of potential/critical risk (Richard et al., 2008; Krishnan and Shulman, 2007; Zsidisin et al., 2000; Giunipero et al., 2004).

The next stage is the risk control which involves selection of a strategy or combination of strategies to counter the risk. Importantly, an effective risk management approach is desired to deliberate the risk control actions. The output/results of the risk management process is reviewed to take into account new knowledge and experience in

risk management (Ritchie and Brindley, 2007; Norrman and Jansson, 2004). Basically, the monitoring and review stage involves measuring the performance of implemented controls by re-assessing risk (Van der Vorst, 2005). As an ongoing process, risk communication involves sharing of information about risk and risk management between the decision-makers and others stakeholders (Johnson, 2001).

Broadly, the risk management process can be categorized into two parts as identification of potential/critical risk and treatment of the potential/critical risk. A summary on stages of risk management process is depicted in Table 3.1.1.

Table 3.1.1: Stages of Risk Management Process

	Stages of risk management process	Definition	Risk Communication	Literature
Identification of Risks	1. Identification & Classification of Risks	Risk can be considered the combination of an event, the likelihood that it will happen and its consequences.	• Identify stakeholders • Consult with stakeholders in defining scope of issue	Krishnan and Shulman (2007), Sodhi (2005), Sinha et al. (2004), Rao et al. (2005), Wu et al. (2006), Liangyuan and Yucheng (2001), Juttner (2005), Cavinato (2004), Kleindorfer and Saad (2005), Agiwal et al. (2008), Paulsson (2004)
	2. Risk Assessment	Risk assessment is a quantitative and/or qualitative estimation of the probability of occurrence and severity of known or potential threat/adverse impact of risk.	• Discussion of source, exposure issues • Communication of results with stakeholders • Assess changes in knowledge/perception in light of new information	Richard et al. (2008), Tsohou et al. (2006), Anderson and Dillon (1992), Faisal et al (2007), Ojala and Hallikas (2006), Sheffi and Rice (2005), Johnson (2001), Finch (2004)
	3. Evaluate Risk Priorities	Determine the contribution of each risk to the aggregate risk profile, and priorities accordingly	• Elicit stakeholder perceptions of the risks and benefits, and the reasons for these, if possible • Assess stakeholder acceptability of the risk	Tsohou et al. (2006), Finch (2004), Richard et al. (2008), Giunipero et al. (2004), Iakovou et al (2007), Wijnands and Ondersteijn (2006), Johnson (2001)
Treatment of Critical Risks	4. Risk Control: Response to Risk/Risk Mitigation/ Treatment	Deliberate actions taken to reduce risk are potential or maintain the risk at an acceptable level.	• Assess stakeholder acceptability of the risk	Peck (2006), Ojala and Hallikas (2006), Christopher and Peck (2004), Johnson (2001), Gaudenzi and Borghesi (2006), Berry and Collier (2007), Allen and Schuster (2004), Twu S-J et al. (2003),
	5. Risk Monitoring	Risk monitoring involves keeping eye on the changes in indicators of identified risks.	• Ensure implementation of communication strategies • Monitor changes in needs, issues, concerns of existing or new stakeholders • Communication of risk control decision and implementation	Berry and Collier (2007), Tang (2006), Lai et al. (2002), Richard et al. (2008), Bichescu and Fry (2009), Forsiund and Jonsson (2007), Yang et al. (2008), Zelbst et al. (2009), Hallikas et al (2005), Kleindorfer and Saad (2005)
	6. Risk Reporting/ Review and Refinement	Risk reporting is about ongoing awareness and the effectiveness of any actions or strategies taken to contain or reduce risk.		Ritchie and Brindley (2007), Norrman and Jansson (2004), Paulsson (2004), Van der Vorst (2005), Persson and Olhagern(2002), Tan (2002), Ritchie and Brindley (2007), Zsidisin et al. (2005)

3.1.2 Risk Management Approach: Clustering

Effective management of agricultural risk required a workable approach with active involvement of all the stakeholders. Having introduced the idea that collective action through organizing farmers into groups and clustering them through interlinking and networking & capacity building can be a potentially successful strategy to help the farming communities, particularly small and marginal farmers (Zvirgzdiņa et al., 2009; Burger, et al., 2001; Bolo, 2006). Clustering offers multi-benefits and empowerment to the farmers (Allen, 2006). The major benefits associated with this approach are economies of scale and lower transaction costs which can enable members to increase their access to inputs and farm services (Burger, et al., 2001). The increased credibility associated with the cluster especially if it is legally registered, also makes it easier for members to access financial services, as financial institutions/banks are more likely to give credit to registered organizations than to individual farmers. Training and capacity building of farmers is the most important factor for adoption of risk management practices (Korpraditskul, 2005; Chi and Yamada, 2002). The good agricultural practices (GAP) can improve the quality which in turn increases the marketability of the produce.

The bargaining power of farmers which refers to the ability to influence the price or terms of a business transaction, increases in the market when the product is scarce and when producers have access to the market information. The clustering approach can increase the bargaining power of farmers by collective marketing of products and negotiating better prices for their produce (Adeya, 2006.). Clustering approach may also help farmers to earn more by value addition activities through invest in primary processing, storage or transport facilities, giving members increased choice over when and where to sell their farm products (Porter, 1998). This also reduces the pre and post harvest losses/wastage. By working as a group, farmers are more likely to access output markets directly including processors, wholesaler and other marketsby bulking their produce together to reach the scale necessary to deal with buyers directly, and bypassing intermediaries (Ghatak and Pandey, 2000; Das and Das, 2011).

3.1.3 Risk Perception

Risk is often described and defined in terms of the probability of an undesirable event occurring and the magnitude of the loss that is associated with the event (Mellers and Chang, 1994). However, a little is known about the relative impact of these two factors in shaping risk perception which is defined as "a decision-makers assessment of the risk inherent in a situation" (Sitkin and Pablo, 1992). Apart from the two variables-risk

perception, the risk propensity- plays a crucial role in decision-making involving risk (Keil et al., 2000). The term 'risk propensity' refers to the notion of decision-makers who have consistent tendencies to either take or avoid actions that they feel are risky (Keil et al., 2000; Sitkin and Pablo, 1992; Harnett and Cummings, 1980). Under the study, risk perception of the vegetable farmers have been taken into account as their risk perception.In agricultural context, risk is perceived not solely by technical parameters and probabilistic numbers, but in farm entrepreneurs' psychological, social and cultural context as well.

The essence of managing risk is about making good decisions and choosing among alternatives to reduce the impact of various types of risk (Läänemets et al., 2011; Narula, 2009; Galloway and Mochrie, 2005; Harwood et al., 1999). Past studies have investigated different socio-economic and farm related factors that affect the choice of risk management strategies by farmers (Pennings, et al., 2008; Chi and Yamada, 2002). Gender, age, education, income were found to be significant determinants of the adoption decision of risk control measures leading to risk reduction (Padel, 2001; Burton et al., 1997). Nahuelhua et al. (2009) investigated that age as a positive and significant variable, suggesting that older farmers are potentially more aware and concerned about agricultural risks. He further found that there was a positive and significant relationship between education and risk management behaviours of the farmers. Chi (2008) resulted that income was a significant factor which positively influence the technology adoption to mange agricultural risks. Nath and Ahmad (2011) investigated that landholdings and agricultural education & access to information were critical factors determining the choice of risk management strategy. Thus, the human capital characteristics play an important role in risk management behaviours and adoption of risk control practices. It should be an important consideration while developing an effective risk management framework.

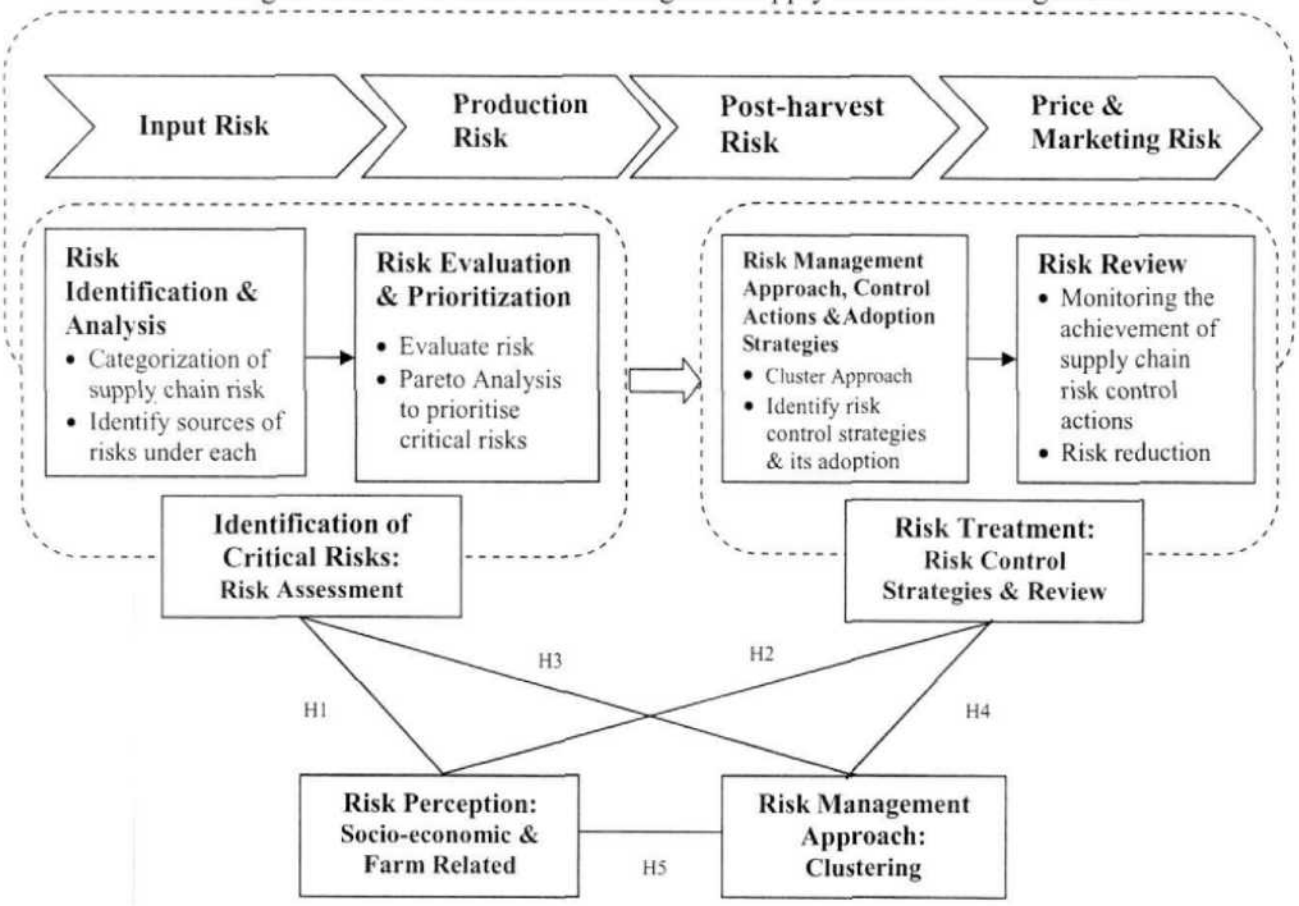
3.1.4 Framework for Integrated Supply Chain Risk Management

The current agriculture environment is demanding a more integrated risk management approach (Bolvin et al. 2007; Treasury Board of Canada, 2001). It is no longer sufficient to manage agricultural risk at the individual stage of supply chain. Farm enterprises around the advanced world are benefiting from a more comprehensive approach to dealing with risks across the supply chain. The sources of risk in agriculture are multiple and diverse, ranging from begining input stage to the consumption as last stage. The supply chain risks that present themselves on a number

of fronts demand a coordinated, systematic response. Thus, integrated supply chain risk management is defined as a continuous, proactive and systematic process to understand, manage and communicate risk from a holistic perspective. Integrated supply chain risk management requires an ongoing assessment of potential risks across the chain and then aggregating the results at the institutional level to facilitate priority setting and improved agricultural decision-making. Integrated supply chain risk management does not focus only on the minimization or mitigation of risks, but also supports important activities that foster innovation, so that the greatest returns can be achieved with acceptable risks (Berg, 2010). The identification, assessment and management of risk across an organization helps reveal the importance of the whole, the sum of the risks and the interdependence of the parts.

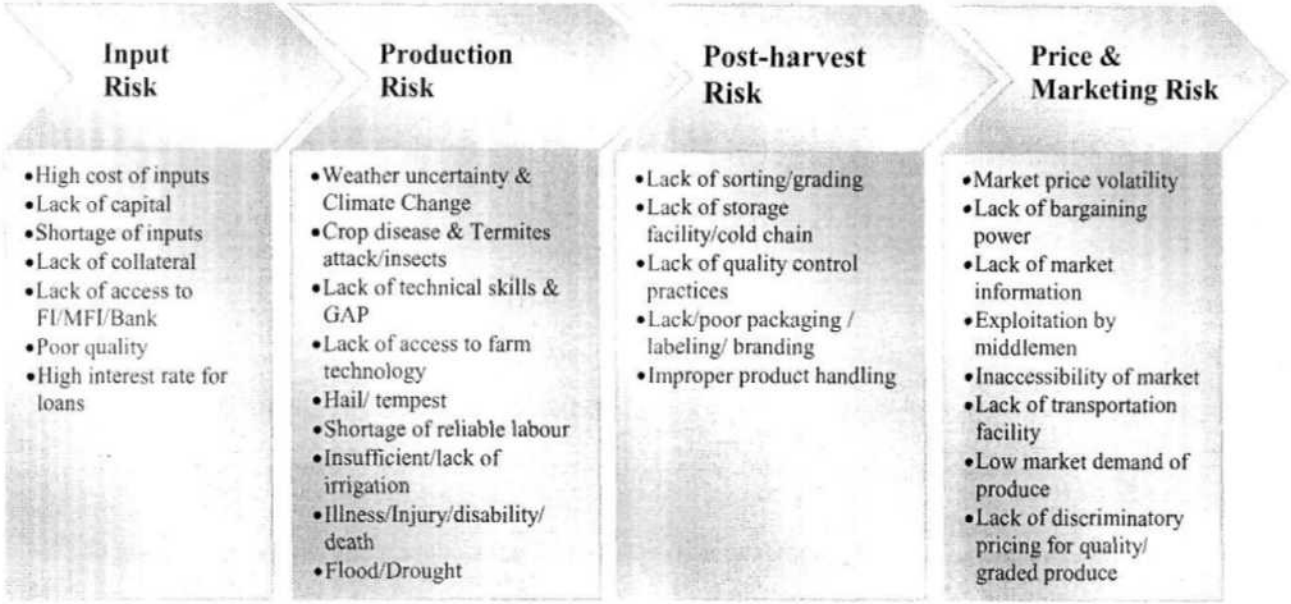
The above discussion provided important insights to develop an integrated framework for supply chain risk management. Agricultural risk management is considerably influenced by the interaction between the risk management approach (as clustering) and farmers' risk perception including their socio-demographics & farm characteristics. The study proposes following conceptual framework for integrated supply chain risk management in agriculture with special reference to vegetables supply chain (Figure 3.1.4a).

Figure 3.1.4a: Framework for integrated supply chain risk management



This framework will include following risk variables at each stage of the supply chain (Figure 3.1.4b).

Figure 3.1.4b: Stages and variables for supply chain risk analysis



3.2 Research Hypotheses

Based on the literature review, following hypotheses have been formulated to understand the risk management processes in upstream vegetable supply chain in India. It was also depicted in the Figure 3.1.4a.

H1: Producers' socio-economic and farm characteristics are more likely to have influence on identification of critical supply chain risks.

H2: Producers' socio-economic and farm characteristics are more likely to have influence on treatment of critical supply chain risks.

H3: Clustering of farmers' group is positively associated with identification of critical supply chain risks.

H4: Clustering of farmers' group is positively associated with treatment of critical supply chain risks.

H5: Producers' socio-economic and farm characteristics are more likely to have influence on cluster formation.

Chapter 4

DATA AND METHODOLOGY

This chapter provides a description of the data and methodology used in this study. Briefly, it discusses about the sampling procedure for data collection, survey instrument, and data analysis procedures and techniques employed in the study. While qualitative data is interpreted and descriptively presented, quantitative data is analyzed using advanced statisticaland data analysis methods and techniques such as Risk Priority Number (RPN), Ishikawa Diagram, Pareto analysis, Chi-square, F-statistics, and coefficient of variation for answering the research questions and testing the hypotheses. The socio-demographics and farm characteristics of the sample are also reviewed.

4.1 Sampling Procedure

Initially, a comprehensive review of the literature on sources of risk in agricultural and risk management strategies was undertaken. Much of existing literature on agricultural risks and risk management uses quantitative methods like systematic surveying to obtain data and information from the farmers (Ali and Nath, 2008). Quantitative methods provide numerical data for examining relationships and differences among variables (McMillan and Schumacher, 2001). It is also invaluable for testing and validating already constructed theories about how and why phenomena occur. For realizing the present study objectives and testing hypotheses, a synthesis of secondary and primary data was used. The secondary data used for the analysis included reputed and relevant sources such as Central Statistics Organization (CSO), National Sample Survey Organization (NSSO), Agricultural Census of India, Ministry of Agriculture GoI, the Food and Agriculture Organization of the United Nations (FAO), journals, books, policy papers, and online agricultural databases. To supplement the secondary data and fill up the gap of earlier findings, the primary data and information were also collected from the field survey using structured questionnaire.

In this stage, several organizations and agencies including NGOs working on the agricultural risk management in several parts of the country were approached. After

evaluating them, the Agricultural Risk Management Pvt. Ltd which is working on vegetable risk management project in the state of Uttar Pradesh was found the most relevant to conduct the present study. The agency with active support from NGOs, agribusiness firms, and Government departments is functional in two districts of Uttar Pradesh namely Allahabad and Ghazipur, and facilitating vegetables farmers starting from the production to the market.

A multi-stage stratified random sampling technique was used for the selection of sample from these two districts (Figure 4.1). The first stage involves purposive selection of two districts namely in the state of Uttar Pradesh. Keeping in view the objectives of the study, the districts were selected on the basis of the implementation of agricultural risk management projects which are being jointly implemented by various NGOs, public and private agencies & gross root level local organizations. A clustering approach was followed by them to get effective result of the innovative intervention.

Second stage involves random selection of development blocks in both selected districts. In consultation with the agencies/organization, a total 20 development blocks (10 from each selected district) were identified where project interventions were made. Out of 10 listed out development blocks from each sample district, a total 3 blocks were randomly selected for the survey. Thus, a total 6 development blocks selected from both sample districts.

At the third stage, development block wise project villages were listed out in consultation with implementing agencies/organizations. A total 20 project villages were listed out from each sample block, out of which 5 project villages were randomly selected for the survey. Finally, a total 15 villages selected from each sample district for the field survey. Thus, the survey was spread over a total 30 villages in the two sample districts. The agencies/organizations were also requested to provide a detailed list of beneficiaries (cluster members) and non-beneficiaries vegetable producers from the representative sample villages, as they have well documented and maintained the updated list of those.

The last stage involved the random selection of a total 10 vegetable growers from each selected village, out of which 5 were cluster members and remaining 5 as

non-cluster vegetable producers in the same village, making a minimum total of 150 from each sample district. Thus, the survey covered a minimum total of 300 vegetable growers from two districts (150 cluster vegetable producers and the same number i.e. 150 non-cluster producers). Following the above sampling procedure, the survey actually covered 329 vegetable growers as per details provided in Table 4.1.

Figure 4.1 Sampling Procedure

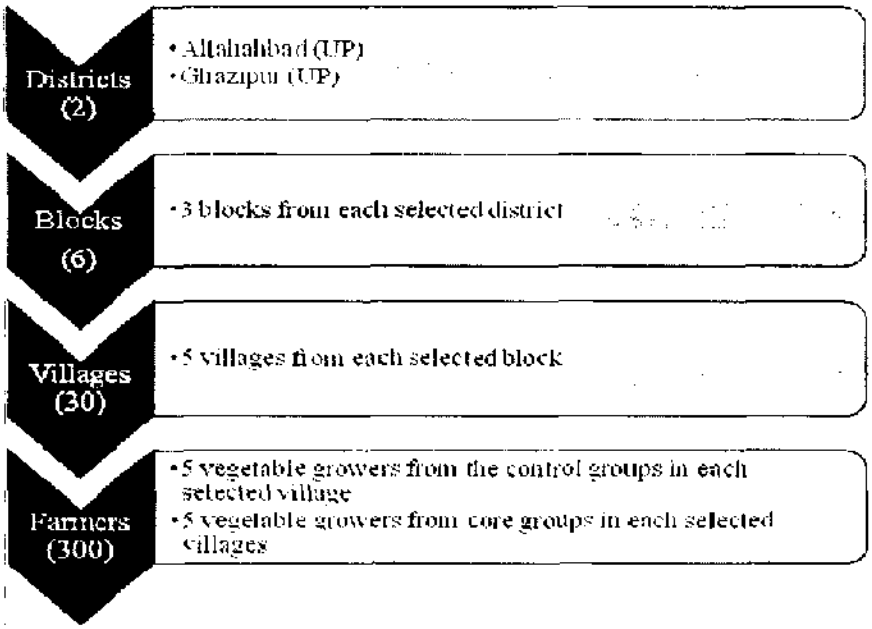


Table 4.1 Sampling distribution

Districts	Block	No. of villages	Cluster members	Non-cluster	Total
Allahabad	Bahadurpur	5	31	27	58
	Baharia	5	28	27	55
	Soraw	5	27	26	53
Ghazipur	Karanda	5	27	28	55
	Mohamnadabad	5	28	25	53
	Sadar	5	30	25	55
Total (2)	**6**	**30**	**171**	**158**	**329**

4.2 Measurement of Risk Perception in Pre-intervention & Post – intervention Situation

A significant amount of research has been available on risk perception and a variety of theoretical perspectives have been adopted from sociological, psychological and cultural viewpoints, among others (Krimsky and Golding, 1992). Risk perception is the subjective assessment of the probability of a risk (Cutchin et al., 2008). The perceived

risk includes evaluations of the probability as well as the consequences of a negative outcome. The measurement of perceived risk is often focused at the probability of occurrence, severity, and detection of risk (Rakotonirainy and Maire, 2005). Risk perception is often measured by a direct method using instrument such as a questionnaire (Vivianne, 2007).

The choice of recall period in perception based studies depends on the variability, duration, frequency, and intensity of the concept measured. There is a trade-off between recall bias and complete sampling information. Clarke et al. (2008) set out this trade-off through an analytical framework and shown that longer the period of recall the greater is the likelihood of recall error, but the shorter the recall period the greater is the problem of missing information. He further suggested that there is no general answer to the question of optimal recall periods, as this question largely depends on the main objective for data collection. In agricultural risk perception and decision making studies, the optimal recall period often long and suitable considering its distinct nature (O'Kane et al., 2009; Chong, 2005).

Under the present study, risk perception of the farmers on various pre-defined parameters were recorded both in pre-intervention (pre-clustering) and post-intervention (post-clustering) status using a survey instrument.

4.3 Survey Instrument and Data Collection

The most important part of the survey process is the questionnaire design for gathering data/information about the targeted population using appropriate sampling method. The formulation of the questions and the structure of the questionnaire are critical to the success of the survey. Questionnaire design is a multiple-stage process which includes details on the target population, includes identified the variables and indicators that addresses the research issues and hypotheses, includes open or close ended questions, scale development, and languages to be used. Dillman (2007) provide as outline for the critical research processes i.e. (1) questionnaire design, (2) pilot-testing and (3) data collection implementation. A well defined research question and clearly defined goals for an intended study is the first step towards questionnaire design. A sincere design of survey questionnaire has significant impact on response rate as well as the ability to capture desired data under study (Matz, 1999; Saphore, 1999). Pilot-testing of newly

design questionnaire through field is essential in order to eliminate problems associated with redundancy of questions, logical flow of questions and sequencing, confusion in question wording and format, terminology, spelling error, and other faults (Flynn et at., 1990). Furthermore, the response rates for filed survey (also called paper & pencil survey) are comparatively high than other mode of surveys (Mertler and Earley, 2003).

For the present study, data were collected with the aid of a self administered structured questionnaire which was designed considering above recommendations and guidelines. The questionnaire has four important sections: socio-economic profile of vegetable growers, assessment of listed sources of risk in supply chain and risk management strategies, and last section as supply chain performance measurement. The first section of the questionnaire brought out the socio-economic and farm characteristics of the respondents, such as age, education, income, social category, and farm size. The Second section assesses risk in vegetable supply chain using indicators for various sources of risks.

Last section intended to measure the supply chain performance. A 10 points' likert type scale (1-2 no/ least risk, 3-4 somewhat risk, 5-6 moderate risk, 7-8 high risk and 9-10 extreme risk) was used to rank the risk profile attributes i.e. severity, occurrence and detection before and after adopting control measures for each source of risk (Spector, 1992; DeVellis, 1991). Considering the low literacy level of the respondents, a scale marked from one to ten was shown to them, and they were asked to rate their positions accordingly.The final questionnaire took an average of 25-30 minutes for a respondent to complete. All the collected data was digitized into SPSS 20.0 application software for data analysis.

4.4 Data Analysis

Before data analysis, data inspection and data cleaning processes such as adjusting missing values, identify and treat outliers were carried out considering the application of statistical techniques for data analysis (Hair et al., 2006; Flynn et at., 1990). Reliability analysis was also conducted to check internal consistency of scales to ensure data quality (Cronbach's alpha >0.700). Statistical analysis was primarily carried out in SPSS 20.0 while data management was handled in Microsoft Excel. Descriptive statistics, frequencies, and cross-tabulations were done to determine demographic profiles (gender, age, education, income and primary occupation) and Risk Priority

Numbers (RPN) and compare the same between cluster and non-cluster groups. The details of various advanced statistical and data analysis techniques which have been used to analyse the data collected and draw conclusions are described below.

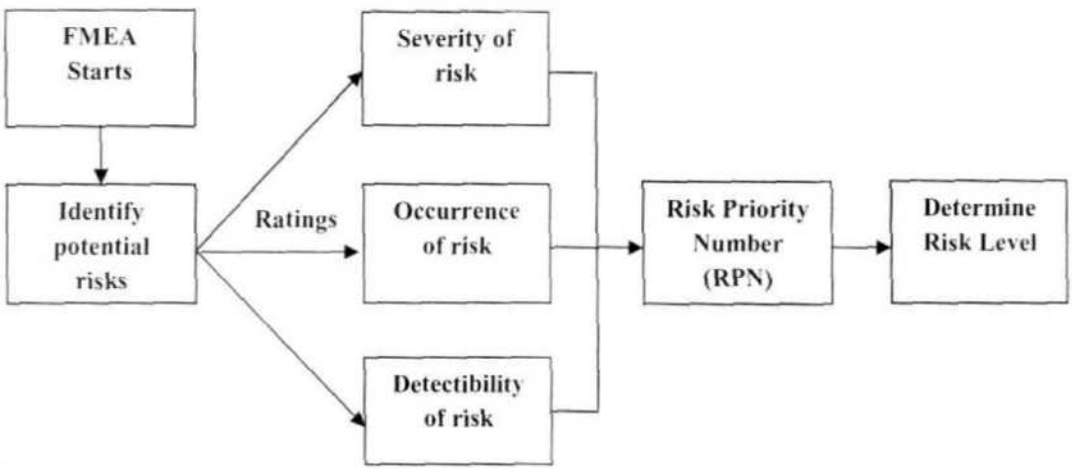
4.4.1 Failure Modes and Effects Analysis (FMEA)

FMEA emerged in 1940 from US Armed Forces to classify failures and then widely used by National Aeronautics Space Association (NASA) for space programs to mitigate risk (Allen et al., 2009). It is now extensively used in a variety of industries including agriculture (Namdari et al., 2011). As exhibited in Figure 4.4.1, FMEA is a systematic process that uses Risk Priority Number (RPN) to assess potential risk at initial and thereafter adopting control measures by ranking of their severity (S), frequency of occurrence (O) and detection probabilities (D), was adopted to determine risk level (Su and Chou, 2008). To describe these three risk variables, the assessment number generally ranges from 1 (no/least risk) to 10 (extreme risk). The RPN is calculated by multiplying the values of the three variables O, S and D. A high value of RPN indicates high level of risk.

$$RPN = Severity \times Occurrence \times Detection$$

Bowles (2003) identified that RPN measurement scale is an 'ordinal' scale. An ordinal scale indicates that an item has more or less of a given attribute in reference to a similar item, but not how much more or less of the given attribute.

Figure 4.4.1: Application of FMEA in determine risk level



Reduction in RPN is estimated by subtracting revised RPN value (as estimated after adopting control measures) from initial RPN score (without any interventions) divided by initial RPN value, as per following formula:

$$\text{Pecentage reduction in RPN} = \frac{RPNi - RPNr}{RPNi}$$

4.4.2 Pareto Analysis

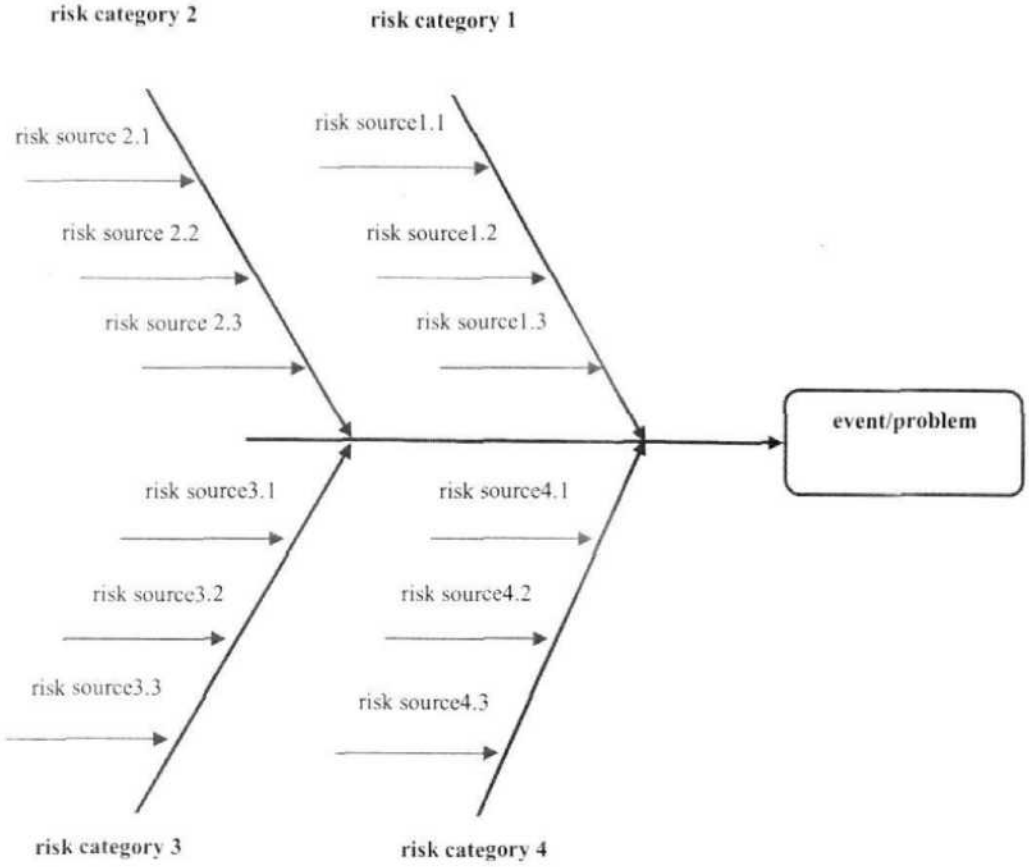
Pareto Analysis is used to prioritize the identified sources of risk across the vegetable supply chain. Pareto Analysis (also called Pareto Diagram/Chart) is based on the Pareto Principle, named for Italian economist Vilfredo Pareto (1848-1923), which elucidated that most of the effects of an action come from a small amount of the causes. This is often called the 80-20 rule, implying that 80% of the failures come from 20% types of defect. A Pareto Analysis is used to visually identify the most important factors, or the most common problems also referred as "the vital few". It is identified by simply look at where the line graph crosses 80% and the categories to the left of that point are called "vital few" or most significant factors.

The purpose of a Pareto diagram is to break down the parts of a problem determining the important and the trivial. Pareto chart is a unique type of bar chart with the values ordered from largest to smallest and a superimposed line graph showing the cumulative total. It summarizes and displays the differences between data groups and their relative importance. It prioritizes direction and focus on the vital few instead of targeting all the categories.

4.4.3 Ishikawa Diagrams

The Ishikawa diagram is a simple technique that helps to structure a risk analysis process (Guebitz e. al., 2012). This tool can be used to systematically determine risk categories and risk sources of a certain event as illustrated in Figure 4.4.3. The overall event or problem is stated at the right end of a horizontal arrow. Risk categories and corresponding risk sources are determined by filling in the ''fishbone.'' The Ishikawa diagram can be used during a FMEA as a facilitation method to identify the critical risks leading to disruptions in supply chain.

Figure 4.4.3: Ishikawa diagram - critical risks and risk sources of an event



4.4.4 Coefficient of Variation

The extent of variability in area, production, and productivity of major agricultural items were analyzed through Coefficient of variation (CV), a relative measure of risk. Mathematically, coefficient of variation is the ratio of the standard deviation of data (data series) and its mean (CV = SD/ Mean). It is usually expressed in percentage.

$$CV = \frac{\sigma}{\bar{x}} \times 100$$

4.4.5 Chi-square Statistics

Chi-square (χ^2) is a statistical test commonly used to compare observed data with data we would expect to obtain according to a specific hypothesis. In other words, chi-square test is used to determine whether there is a significant difference between the expected frequencies and the observed frequencies in one or more categories.

$$\chi^2 = \frac{(O-E)^2}{E}$$

Where, O is the observed frequency

E is the expected frequency

4.4.6 Analysis of variance (ANOVA)/ F-Statistics

The F-test in one-way analysis of variance is used to assess whether the expected values of a quantitative variable within several pre-defined groups differ from each other. The F-test is used to test for differences among sample variance. The formula for the one-way ANOVA F-test statistic is:

$$F = \frac{explained\ varience}{unexplained\ varience}$$

or

$$F = \frac{between - group\ variability}{within - group\ variability}$$

4.5 Socio-demographic Profile of Respondents

Table 4.5 reports summary profile of cluster and non-cluster surveyed vegetable producers with respect to gender, age, education, social category, occupation, household income and landholding size. Of the 329 respondents, 171 respondents i.e. 52% reported to be vegetable cluster members while the remaining 158 (48%) were non-cluster vegetable producers. An overwhelming percentage (81%) was male participants and a satisfactorily 18 percent female (19%). There is no significant difference was found in the gender distribution pattern between cluster and non-cluster members.

A fairly equal distribution of experience in vegetable cultivation was realized with a mix age groups of younger adults (<20 years, 21.6%), mature-adults (20-35, 24.7%), middle-aged adults (36-55, 33.3%), and young-old (>55 years, 20.4%). Almost the same age distribution pattern was found between cluster and non-cluster members, as no statistically significant differences were estimated. However, the cluster members were more experienced in vegetable cultivation with an average age of 40 years as compared to non-cluster members who stand at 36 years. More than 40 percent respondents were illiterates or having basic knowledge and /or ability to read, write and/or calculate that need to use in everyday life. This group predominated (47.5%) the cluster population. The remaining majority have some schooling or a college degree in

both the groups. The chi-square tests revealed that there was no significant difference in education levels between cluster and non-cluster participants.

Table 4.5 Profile of cluster and non-cluster respondents

	Total		Cluster		Non-Cluster		Chi-square/F-Statistics
	N	%	N	%	N	%	
Gender							
Male	266	81.1	134	78.4	132	84.1	$\chi^2 = 1.743$ $p=0.119$
Female	62	18.9	37	21.6	25	15.9	
Age (years)							
<20	71	21.6	35	20.5	36	22.9	$\chi^2 = 6.328$ $p=0.097$
20-35	81	24.7	38	22.2	43	27.4	
36-55	109	33.3	54	31.6	55	35.0	
>55	67	20.4	44	25.7	23	14.6	
Education							
Illiterate/Literate	142	43.2	81	47.4	61	38.8	$\chi^2 = 4.593$ $p=0.332$
JHS and below	66	20.1	36	21.1	30	18.8	
Secondary/Higher Sec.	80	24.3	39	22.8	41	25.9	
Graduate/PG	31	9.4	12	7.0	19	11.8	
Professional/Diploma	10	3.0	3	1.8	7	4.7	
Social Category							
General	42	12.8	18	10.5	24	15.3	$\chi^2 = 4.542$ $p=0.103$
OBC	220	66.9	125	73.1	95	60.0	
SC	67	20.4	28	16.4	39	24.7	
Primary Occupation							
Agriculture/Farming	176	53.5	97	56.7	79	50.0	$\chi^2 = 7.857$ $p=0.164$
Service	16	4.9	8	4.7	8	5.1	
Business	11	3.3	5	2.9	6	3.8	
Labourer	25	7.6	17	9.9	8	5.1	
HW	39	11.9	20	11.7	19	12.0	
Student	62	18.8	24	14.0	38	24.1	
Yearly household income (₹)							
<25K	49	15.0	23	13.6	26	16.5	$\chi^2 = 19.422$ $p=0.001$
25K-50K	82	25.1	34	20.1	48	30.6	
51K-75K	71	21.7	32	18.9	39	24.7	
76K-1L	42	12.8	16	9.5	26	16.5	
>1L	83	25.4	64	37.9	19	11.8	
Land holdings							
Marginal	82	24.9	50	29.2	32	20.3	$\chi^2 = 5.093$ $p=0.165$
Small	102	31.0	52	30.4	50	31.6	
Medium	93	28.3	41	24.0	52	32.9	
Large	52	15.8	28	16.4	24	15.2	
Farm Training							
Yes	171	52.0	171	100.0	0	0.0	$\chi^2 = 329.000$ $p=0.000$
No	158	48.0	0	0.0	158	100.0	
Exposure Visits							
Yes	19	5.8	14	8.2	5	3.2	$\chi^2 = 3.807$ $p=0.041$
No	310	94.2	157	91.8	153	96.8	
Average size of land (ha)	2.33		2.42		2.24		$F=0.667$ $p=0.415$

In terms of social category, a majority (66.9%) of the respondents were belonging from socially backward groups (OBC). This group was comparatively predominated in the cluster group however, statistically, no significant difference was found as of social distribution pattern is concerned between the both groups. By far, the most prevalent profession of the surveyed participants observed as farming (53.5%). The average annual income of cluster members estimated significantly higher to the tune of Rs. 1,00,672 as compared to non-cluster producers Rs. 60,517.Also, the Chi-square test indicates the significant difference (χ^2 =19.422, $p<0.01$) in income status between cluster and non-cluster groups with improved income status by cluster participants. Importantly, more than 37 percent cluster participants fall in the extreme income range of more than one lakh annually. However, the most common income brackets for both groups lie between Rs. 25,000 - Rs.75,000 annually.

Vegetable cultivation was observed the major source of agricultural and household's income by the both groups. Farm trainings, as it was an integral component of capacity building of cluster members, has been attended by all the cluster members. None of the non-cluster producers attended any training on agricultural aspects. However, about 8 percent cluster members and some 3 percent non-cluster participants went for formal exposure visits/learning journeys. In addition, for both the groups, the average household/family size was estimated to 7; average number of working members were 3 (out of which 2 were male and 1 female); and on an average 3 children in each family.

Chapter 5

RESULTS AND DISCUSSION

This chapter is based on primary data analysis and the results are presented into two different sections A & B. Section- A presents analysis result on risk identification and prioritization across upstream vegetable supply chain. Detailed risk evaluation analysis using risk matrix and Pareto Analysis were presented across the stages of supply chain. In addition, it investigates socio-demographic factors that affect the identification and management of critical risks across the chain. Section- B presents the impact analyses of clustering approach on management of critical risks across the vegetable chain, and also compares risk control strategies adopted by cluster and non-cluster farmers using chi-square statistics. This section also provides a detail analysis on how the level of risk at all stages of the supply chain has been affected after the intervention of the organisations at the farm gate.

Section- A

5.1 IDENTIFICATION OF CRITICAL RISKS ACROSS VEGETABLE SUPPLY CHAIN

(Pre-Clustering Intervention Assessment)

5.1.1 Identification of Sources of Risk Across Vegetable Supply Chain

Risk management is a systematic process of identifying, analyzing, evaluation, prioritizing, risk control, and review of performance (Sinha et al., 2004; Richard et al., 2008; Finch, 2004; Johnson, 2001; Berry and Collier, 2007; Paulsson, 2004). Risk identification is the primary step of risk management process, involves determining risks that are likely to negatively affect the farm enterprise. Risk analysis is an umbrella term that based on risk assessment provides the degree of vulnerability of the identified risk and the same to be communicates to the stakeholders to develop effective risk counterstrategies. Risk assessment typically involves quantitatively and/or qualitatively assessment of risks based on probability of occurrence, severity of impact and detection

probabilities (Vanany et al., 2009; Kleindorfer and Saad, 2005). Risk perception which is the subjective judgment that one can make about the risk attributes (occurrence, severity and detection) of a risk, is very important consideration to understand the enterprise risk management behaviors.

To investigate the risk management process across the upstream vegetable supply chain, the vegetable growers' perception on various sources of risks which were listed to ascertain four categories as input, production, post-harvest, and marketing/price; were recorded to understand the potentiality of the identified risk. The perceived risks were analyzed using Risk Priority Numbers (RPN) that measures a relative risk ranking. The higher the RPN, the higher is the potentiality of risk.

Table 5.1.1a presents the sources of input risk along with the computed average RPN value for each perceived risk. Out of the eight sources of input risks, high cost of inputs (RPN=838), lack of capital (RPN=729), shortage of inputs (RPN=613), timely unavailability of inputs (RPN=285) and lack of collateral (RPN=269) were perceived as potential sources of risk. The high costs of farm input coupled with limited financing and credit facilities have resulted in low use of farm inputs and poor investment in farm business. This economic marginality of the farm households is more serious to marginal and small farmers who are unable to arrange collateral to access capital. In addition, getting quality inputs such as seed (improved with desirable trait) and fertilizers were very hard to find on time. The F-statistics indicate that, in pre-intervention situation, there were no significant differences between cluster and non-cluster producers' in average RPN values of different sources of input risk.

Table 5.1.1a: Identification and assessment of potential sources of input risk

Sources of input risk	Total	Cluster	Non-Cluster	F-Statistics	Sig.
High cost of inputs	838	844	827	1.392	0.239
Lack of capital	729	730	727	0.047	0.829
Shortage of quality inputs	613	616	609	0.150	0.699
Timely unavailability of inputs	285	285	286	0.006	0.940
Lack of collateral	269	266	274	0.539	0.463
Lack of financial inclusion	215	212	222	0.714	0.399
Poor quality	164	161	171	1.789	0.182
High interest rate for loans	157	159	153	0.622	0.431

Source: primary survey

The results of perceived sources of production risk in vegetables are presented in Table 5.1.1b. Of the ten sources of production risk, weather uncertainty/climate change (RPN=845), lack of technical skills/GAP (RPN=727), crop disease/termites attack/insects (RPN= 722), lack of access to farm technology (RPN=222), lack of irrigation (RPN=124) and hail/tempest (RPN=121) were perceived as potential risks. In pre-clustering situation, there were no significant differences between the cluster and non-cluster producers in average RPN values of different sources of production risks.

The production risks which concerning yields and actual output & income, generally arise from the natural event such as adverse weather conditions and crop diseases. Although weather is an important production factor in agriculture, it is significant risk factor due to day-to-day variations in the atmosphere, this includes precipitation, temperature, humidity and cloud cover. Further, production risk is often perceived by farmers as being more formidable in new technologies and adoption of Good Agricultural Practices (GAP). Currently, GAPs are not regulations in the country but under consideration by the Governments to provide recommendations and guidance to the agriculture to reduce the risks (FAO, 2001).

Table 5.1.1b: Identification and assessment of potential sources of production risk

Sources of production risk	**Total**	**Cluster**	**Non-Cluster**	**F-Statistics**	**Sig.**
Weather uncertainty & Climate Change	845	853	829	2.913	0.089
Lack of technical skills & knowledge of GAP	727	719	741	2.371	0.125
Crop disease & Termites/insects	722	720	726	0.140	0.709
Lack of access to farm technology	222	222	223	0.012	0.913
Lack of irrigation	124	125	122	0.152	0.697
Hail/ tempest	121	122	119	0.388	0.534
Illness/Injury/disability/ death	89	88	90	0.158	0.691
Flood	65	65	66	0.000	0.994
Drought	63	63	65	0.430	0.512
Shortage of reliable labour	63	62	65	1.015	0.315

Source: primary survey

After the crop harvest, post harvest loss is a major risk factor particularly for perishable crops. The perceived sources of post-harvest risk are exhibited in Table 5.1.1c. The average RPN values indicate that lack of sorting/grading (RPN=845), lack of storage facility & cold chain (RPN=841), poor quality control practices (RPN=833), Poor Packaging (RPN=170), and Improper Product Handling (RPN= 126) were perceived as potential sources of post-harvest risk. An explaining to this is that, the

farmers generally lack the know-how and skills to take advantage of value-added activities such as cleaning, sorting, grading, packaging, labeling, storage, processing, and quality control, which increases value and self-life of produce. As a result, huge losses and wastages of produce are caused. By definition, post-harvest loss is a "measurable quantitative and qualitative loss of the food products" at any moment along the chain; and includes the change in the availability, edibility and wholesomeness of the food that prevents it from being consumed (De Lucia and Assennato, 1994; FAO, 1989). The main causes are physiological (wilting, shriveling, chilling injury, etc), pathological (decay due to fungi and bacteria) and physical (mechanical injury), being these causes in many instances interrelated, i.e. mechanical injury can lead to post-harvest decay in many cases. According to FAO, the crop losses occurs in handling, processing, and storage are comparatively high in developing countries than the developed world, this is largely due to poor facilities and inadequate technical knowledge of methods to care for the food properly. In addition, lack of sorting/grading and poor packaging are major problems in the country, which often lead to marketing failure of the crops.

Like input and production stages of the chain, in pre-intervention situation, there were no significant differences between cluster and non-cluster participants in the average RPN scores of different sources of post-harvest risk.

Table 5.1.1c: Identification and assessment of potential sources of post-harvest risk

Sources of post-harvest risk	Total	Cluster	Non-Cluster	F-Statistics	Sig.
Lack of sorting/grading	845	851	832	2.094	0.149
Lack of storage facility/cold chain	841	845	832	0.994	0.320
Lack of quality control practices	833	840	819	2.130	0.146
Poor packaging	170	175	161	3.193	0.075
Improper product handling	126	125	127	0.208	0.648
Lack of labelling	123	123	124	0.052	0.820
Lack of branding	42	43	40	0.856	0.356

Source: primary survey

Marketing is perhaps the most important activity in farm business because it has a direct effect on profitability and income of producers. Table 5.1.1d provides average RPN scores for various perceived sources of marketing and price risk. Out of nine sources of the risk, the major sources of risk perceived were lack of bargaining power (RPN=862), market price volatility (RPN=836), lack of market information (RPN=730), exploitation by middlemen (RPN=720), inaccessibility of market

(RPN=493), and lack/poor transportation facilities (RPN=434). In addition, producers' were also stressed for low demand of produce and lack of discriminatory pricing for sorted & graded vegetable produces. In pre-intervention situation, there were no significant differences between cluster and non-cluster participants in the average RPN scores of different sources of marketing & price risk.

Marketing food products, for many farmers, is the most difficult than producing them. In the country like India where more than 80 percent vegetable growers are small-scale (<2 ha), the individual farmers produce very little marketable surplus and hence lack in economies of scale and thereby poor bargaining power at the market place. The high market prices fluctuations (input and output prices) are largely due to underdeveloped agricultural markets in the country. In addition, due to poor extension facilities and lack of managerial training, majority of producers in the country lack the marketing skills, as a result they are exploited by local middlemen. Other constraints limiting access to reliable and competitive produce markets besides marketing skills are inadequate market outlets & lack of access to market information. According to IFAD, difficult market access restricts opportunities for income-generation to farmers. The farmers need access to competitive markets not just for their produce but also for inputs, assets and technology, consumer goods, credit and labour. The marketing of food products do not only involve the knowledge of customers' needs but also require good understanding of the supply and demand conditions in the market. Indian farmers, however, generally have poor understanding of supply and demand, and how these forces create markets. Farmers' inability to market produce means lack of income for production inputs, consumer goods and immediate cash requirements, and prevents asset accumulation. Market access thus influences farmers' production systems.

Table 5.1.1d: Identification and assessment of potential sources of marketing & price risk

Sources of marketing & price risk	Total	Cluster	Non-Cluster	F-Statistics	Sig.
Lack of bargaining power	862	857	872	2.046	0.154
Market price volatility	836	838	833	0.138	0.710
Lack of market information	730	725	740	1.028	0.312
Exploitation by middlemen	720	726	708	1.273	0.260
Inaccessibility of market	493	482	516	2.936	0.088
Lack of transportation facility	434	437	428	0.332	0.565
Low market demand of produce	272	276	264	1.393	0.239
Lack of discriminatory pricing for quality/graded produce	91	92	87	0.344	0.558
Difficulties at market place	42	44	38	2.871	0.091

5.1.2 Risks Evaluation Matrix and Risk Prioritisation

Once the risks have been identified and assessed, the next stage involves the evaluation of risks which facilitate decision making. The purpose of evaluation is to compare the levels of risks based on quantitative assessment of risk and decide whether the level of each risk is acceptable or not. There may also be a number of risks that fall into almost the same level and where each of them would not be treated equally. Not all risks are worth taking and hence identifying those with the greatest loss and the greatest probability of occurrence and severity and absolute uncertainty of detection; is an important step towards managing risk by dealt with critical few. Risk matrix is an important method to evaluate the risk (based on risk assessment in terms of probability of occurrence and severity magnitude) and determines whether risk is intolerable, tolerable or acceptable. The RPN gives us an excellent tool to prioritize by identifying critical risks though the Pareto Chart in order to make focused improvement efforts. The RPN adds 'detection' as third dimension to the risk with already existing 'occurrence' and 'severity'.

5.1.2.1 Risk Evaluation Matrix

Multiple techniques have been developed for risk assessment and evaluation. The risk matrix developed based on assessment of categorized sources of supply chain risks is exhibited in Table 5.1.2.1. Of the four categories of sources of supply chain risk perceived, the unacceptable level of risk identified were: high cost of inputs, weather uncertainty & climate change, lack of sorting & grading, lack of storage facility, lack of quality control practices, market price variability, lack of market information, and lack of bargaining power. Whereas, the high level risks perceived were, shortage of inputs, lack of capital, lack of technical skills & knowledge of GAP, crop disease & termites attack/insects, lack/poor transportatiun facility, inaccessibility of market, and exploitation by middlemen. Under the moderate category of risks were poor quality and timely unavailability of input, lack of access to financial institutions, lack of collateral, poor packaging, and lack of market demand/over production. The remaining sources of supply chain risks were perceived had least potential.

Table 5.1.2.1: Risk matrix (Risk=Likelihood x Severity)

Risk Level → Risk Category ↓	Low: ≤25	Moderate: 26-50	High: 51-75	Unacceptable: 76-100
Input	• High interest rate for loans (25)	• Poor quality (27) • Timely unavailability (39) • Lack of access to FI/MFI/Bank (35) • Lack of collateral (40)	• Shortage of quality inputs (66) • Lack of capital (72)	• High cost of inputs (81)
Production	• Illness/Injury/disability/ death (19) • Flood (16) • Drought (16) • Insufficient/lack of irrigation (22) • Shortage of reliable labour • Expensive farm labour (22) • Hail/ tempest (25)	• Lack of access to farm technology (31)	• Lack of technical skills & knowledge of GAP (72) • Crop disease & Termites attack/insects (74)	• Weather uncertainty & Climate Change (80)
Post-harvest	• Lack of branding (11) • Improper product handling (22) • Poor/lack of labelling (23)	• Lack/poor packaging (29)		• Lack of sorting / grading (81) • Lack/poor storage facility /cold chain (81) • Lack/poor quality control practices (80)
Marketing/ Price	• Difficulties at market place (11) • Lack of discriminatory pricing for quality/graded produce (19)	• Low market demand of produce/over production (42)	• Lack/poor transportation facility (56) • Inaccessibility of market (60) • Exploitation by middlemen (70)	• Market price volatility (81) • Lack of market information (76) • Lack/poor bargaining power (77)

SEVERITY →										
10	10	20	30	40	50	60	70	80	90	100
9	9	18	27	36	45	54	63	72	81	90
8	8	16	24	32	40	48	56	64	72	80
7	7	14	21	28	35	42	49	56	63	70
6	6	12	18	24	30	36	42	48	54	60
5	5	10	15	20	25	30	35	40	45	50
4	4	8	12	16	20	24	28	32	36	40
3	3	6	9	12	15	18	21	24	27	30
2	2	4	6	8	10	12	14	16	18	20
1	1	2	3	4	5	6	7	8	9	10
LIKELIHOOD OF OCCURRENCE →										

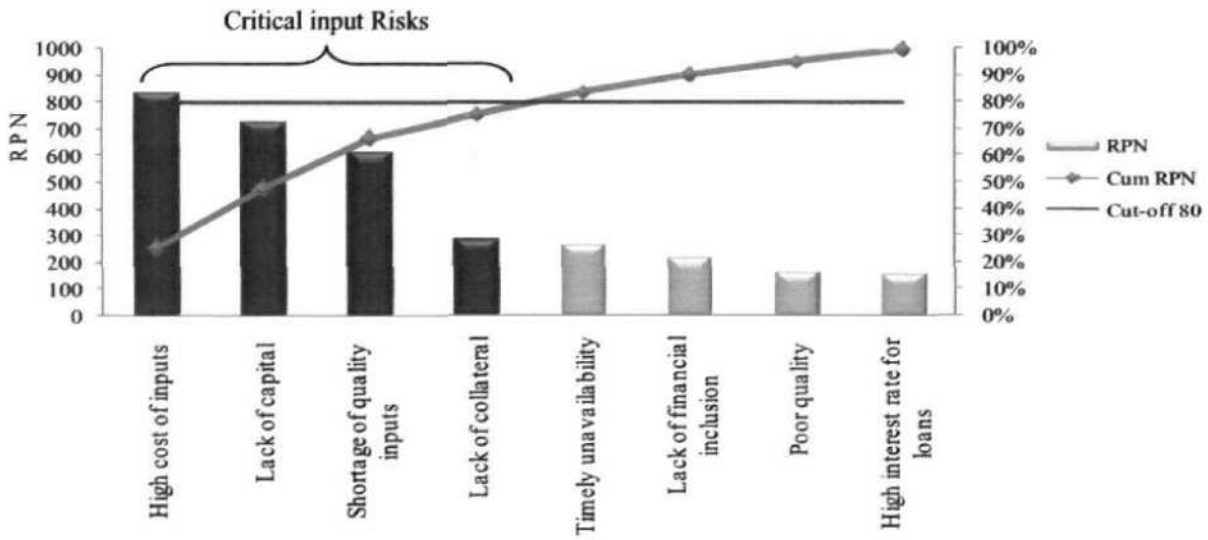
5.1.2.2 Prioritization of Risks Across Supply Chain: Pareto Analysis

Risk prioritization goes beyond risk assessment and evaluation in that it identifies the likely targets. A proven method to prioritise risks is the Pareto Analysis or Pareto Chart which is a histogram that visually identify the most significant 20 percent risks as 'vital few' or critical risks, and the least significant 80 percent risk. The prioritisation analysis results across supply chain are discussed below.

5.1.2.2.1 Prioritisation of Critical Input Risks

In order to prioritise the sources of input risk, Pareto analysis was conducted blending to the FMEA. Figure 5.1.2.2.1 represents the Pareto Chart which clearly displays that out of eight sources of input risk four sources namely high cost of inputs, lack of capital, shortage of quality inputs, and lack of collateral to invest in vegetable enterprise were identified as the critical input risks. Result envisages that investment capital (financial & working) is major constraint to the farmers for agricultural investments. This also indicates that farmers gradually adopting more capital intensive methods of farming than substance oriented traditional farming. That is why they need more capital to buy high-tech varieties of quality seeds and other farm technologies. Indian agriculture is characterized by marginal and small farmers who often lack of collateral to get institutional farm credit coupled with high cost of inputs, led to economic marginality for farm investment. Therefore, making agricultural investments work for small-scale farmers it urgently required managing these critical input risks.

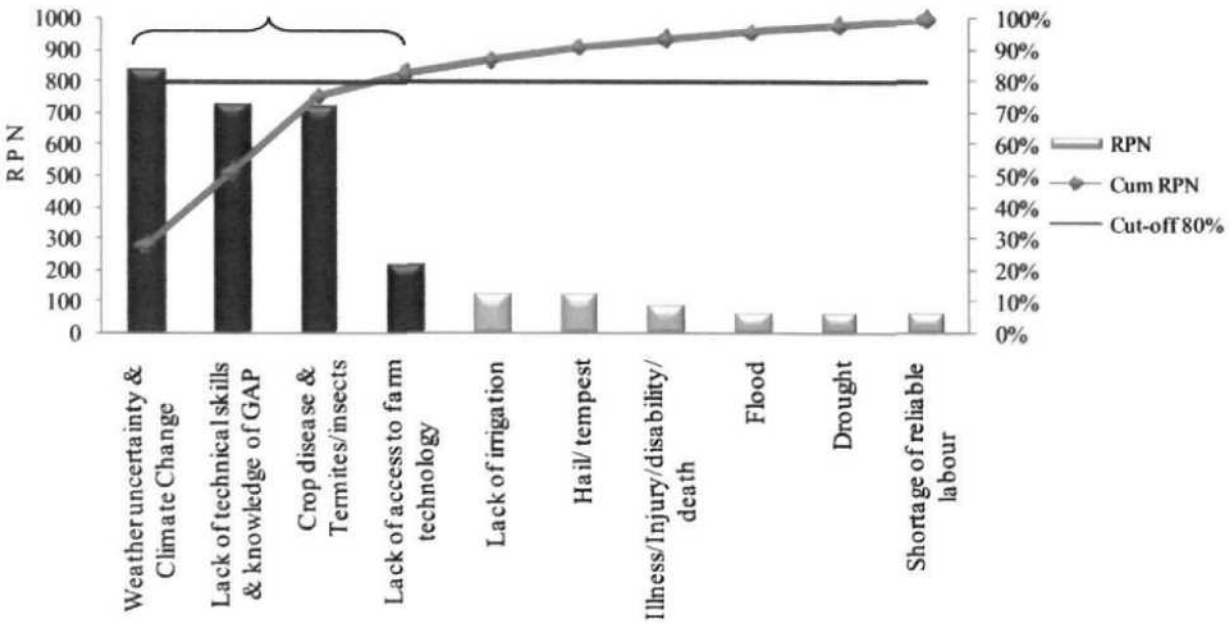
Figure 5.1.2.2.1: Critical input risks



5.1.2.2.2 Prioritisation of Critical Production Risks

Agricultural production is inherently dependent on weather, climate and irrigation water availability, and is adversely affected by any deviation from normal and natural disasters such as flood, hail, tempest, and drought. This stochastic nature of agricultural production is a major source of risk to farmers. The most pervasive production risks in agriculture prioritised by the Pareto Chart (Figure 5.1.2.2.2). The critical production risks identified were weather uncertainty/climate change, lack of technical skill/GAP, crop diseases/ termites attack/ insect, and lack of access to farm technology. The production volatility is mostly driven by uneven rainfall as well as climate change. Crop diseases and Pests have threatened farmers since farming began and causes huge cop losses in the range of 10-15 percent (Dhaliwal et al., 2010; Birthal, 2004). Further, the criticality was added by lack of access to farm technology and lack of technical skill & Good Agricultural Practices (GAPs) in the production chain. Managing critical production risks is the need of time to accelerate agricultural production in order to meet growing global demand for food and energy, but is also seen as the main pathway out of poverty for many poor people and developing countries.

Figure 5.1.2.2.2: Critical production risks

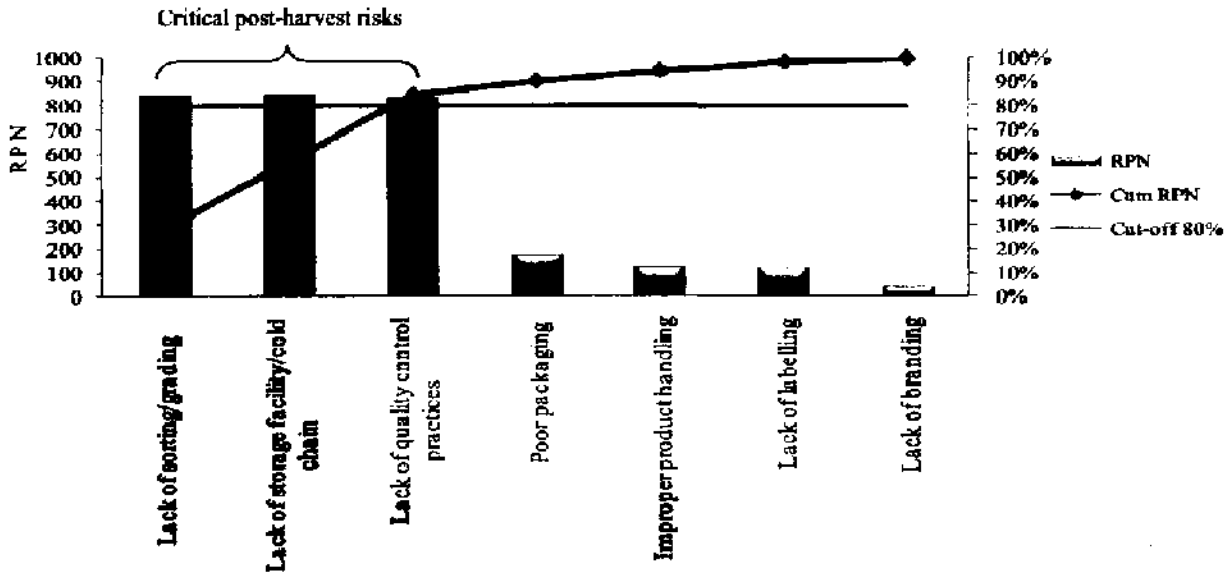


5.1.2.2.3 Prioritisation of Post-harvest Risks

Farmers are affected by both pre and post-harvest risks and uncertainties. Post-harvest losses in agriculture are major source of risk which causes potential losses to both farmers and the rural economy. Risk associated with post-harvest losses may include improper harvesting, handling, packaging, loading and transportation (Acedo and Weinberger, 2006). High level of post-harvest losses were recorded in intensive and underdeveloped rural areas due to lack of proper inland transportation facilities and not follow-up of regulations (uncovered trucks, over loading, transportation in non-refrigerated trucks, road nets are not always in good shape) (Rajagopal, 2002; Basavaraja et al., 2007). Post-harvest losses are extremely high in developing countries such as India, which are exacerbated by poor marketing, distribution and storage facilities.

Critical post-harvest risks as prioritized by the Pareto Chart were lack of sorting/grading, lack of storage/cold chain facilities, and lack of quality control practices (Figure 5.1.2.2.3). Effective management of critical post-harvest risks can not only to minimise losses but also to increase market value of farm produce. Good processing practices can allow preserving product quality at every stage of the chain. There is also requirement of training to the farmers and other stakeholders for attractive packaging to make product more appealing to consumers who are therefore willing to pay more if the product offered is of good quality and easy to use.

Figure 5.1.2.2.3: Critical post-harvest risks



5.1.2.2.4 Prioritisation of Critical Marketing & Price Risks

The marketing of crop produce has become one of the critical areas where the farmers are struggling and highly exploited in the country. Market risks are a result of both variations in supply and demand for crops that are not subjected to binding price controls and from the inability of controlled markets to respond timely and efficiently to changes in the market conditions. Market risks are also associated with the uncertainty about future prices of inputs and outputs and reliability of input supplies (Hardaker et al., 1997). The markets have been affected by macro-economic disturbances, disease outbreaks and adverse weather events such as floods and droughts. There are increased incidences of market failure due to asymmetric information between farmers and other supply chain stakeholders and lack of proper government supervision. With agricultural policies that are more decoupled from production and prices, farmers are now more exposed to market forces than in the past.

The critical marketing and price risks as identified by the Pareto Chart were lack of bargaining power, market price volatility, lack of market information, exploitation by middlemen, and inaccessibility of market (Figure 5.1.2.2.4). Small-Scale farmers in the country have little control over market risks but there are strategies they can use to increase the economies of scale and bargaining power in order to get proper return of their investments.

Figure 5.1.2.2.4: Critical marketing & price risks

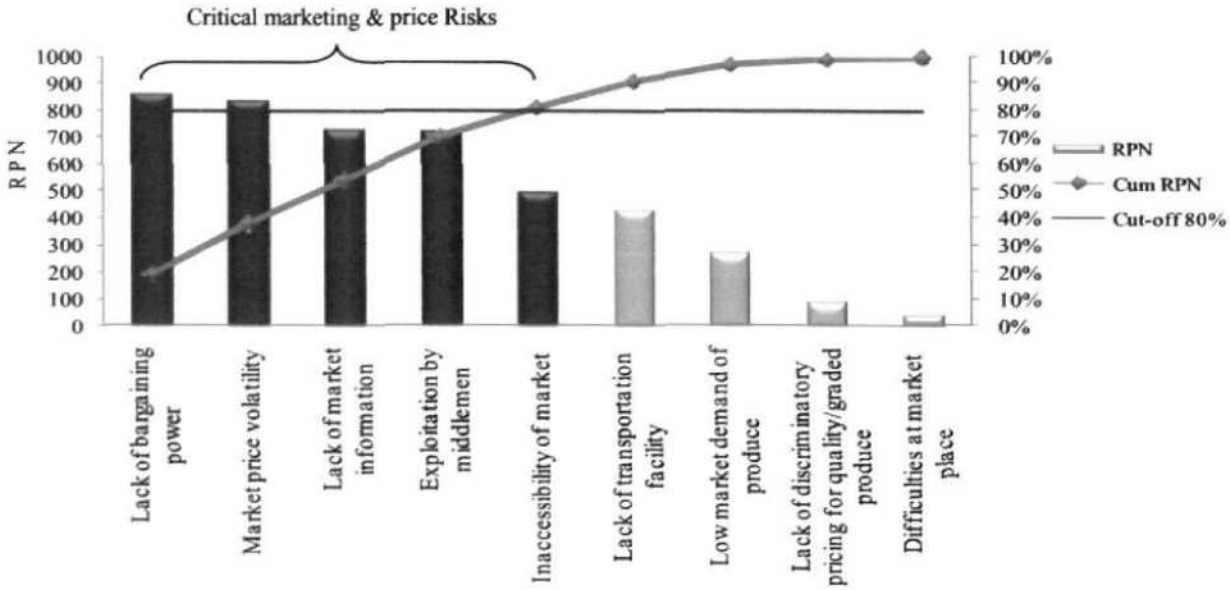
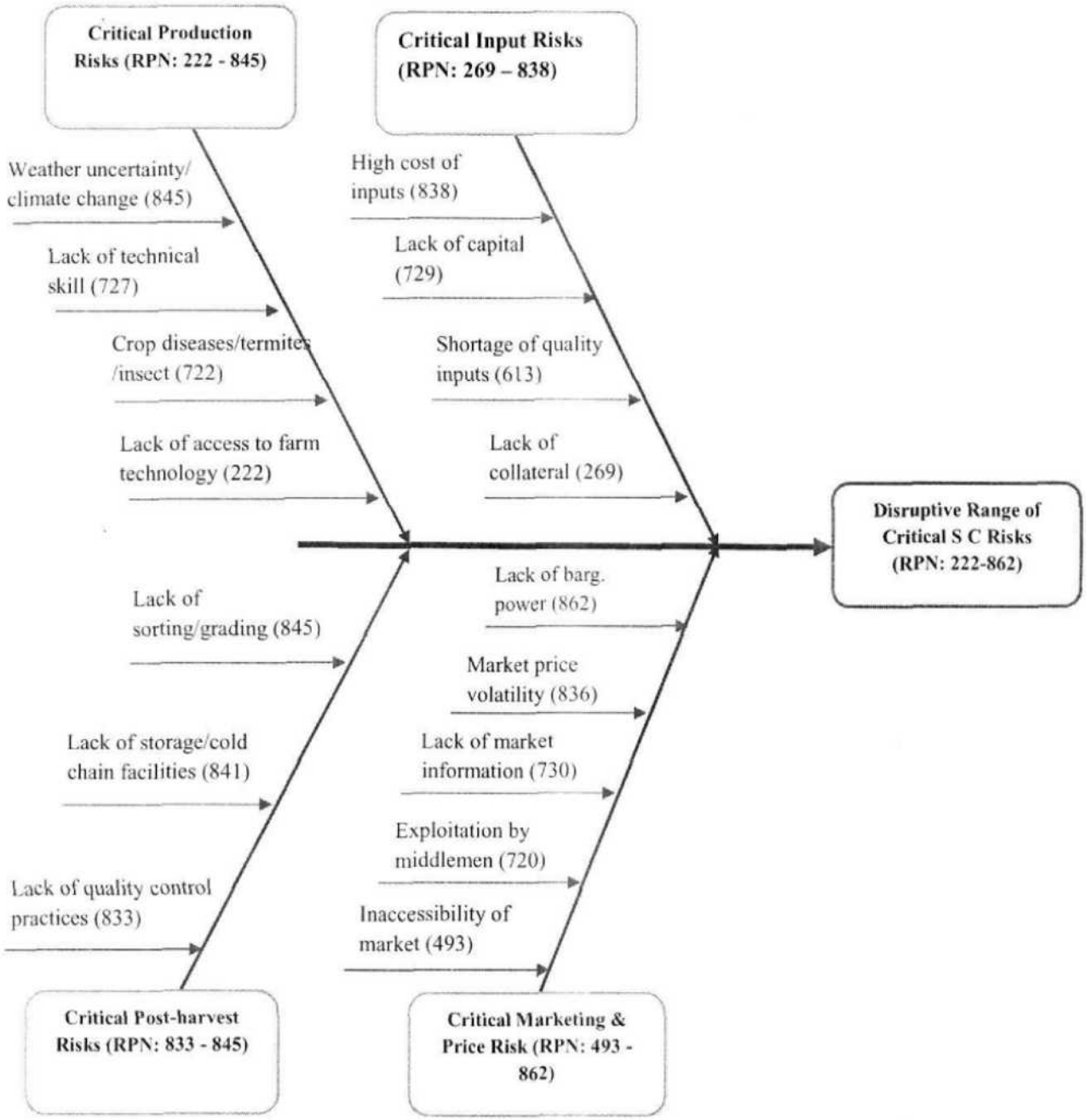


Figure 5.1.2.2.5: Ishikawa diagram - Disruptive ranges of critical risks across the supply chain



Thus, the vegetable growers face a spectrum of risks under each phase of supply chain, however all risks are not significantly important. Only the critical risks are important therefore, it is required to respond them though effective control actions and adoption strategies. Effective management of critical risks are not only important to meet growing global demand for food and energy, but is also seen as the main pathway out of poverty for massive rural poor particularly, small-scale farmers.

5.1.2.2.5 Disruptive Range of Critical Supply Chain Risks: Ishikawa Diagram

Out of a total 34 identified sources of risk across the vegetable supply chain, the Pareto Chart prioritized a total 16 high potential critical risks as indicated at the supply chain stages of input, production, post-harvest, and marketing & price. The disruptive range of critical risks at various stages of supply chain is exhibited in Ishikawa diagram (Figure 5.1.2.2.5).

Of the four stages of vegetable supply chain under the study, the disruptive range of all critical risks lies between RPN (minimum 222 – maximum 862). The disruptive range of critical risks at each stage of supply chain risk was estimated as: input risk RPN (269 – 838), production risk RPN (222 - 845), post-harvest critical risk RPN (833 - 845), and marketing & price risk RPN (493 - 862).

The Ishikawa diagram confirms that the producers face a spectrum of high potential/critical risks at each stage of vegetable supply chain. However, the potential of critical risks may vary to different socio-economic and farm groups. Considering the high potential of critical risks and marginalized status of majority of country farmers, there is strong need to respond them through effective control actions and adoption strategies. Effective management of critical risks is not only important to meet the future need of food & nutritional security, but is also seen as the main pathway out of poverty for marginal and disadvantaged farm groups.

5.1.3 Critical Supply Chain Risks Across Socio-Demographics and Farm Groups

Agricultural risks are socially detrimental. Critical risks were examined across demographics and farm groups using analysis of variance (ANOVA) to assess if there is any significant difference in the average RPN values. Important demographic and farm related decision variables identified were gender, age, education, social category, household income, landholdings and farm category. Results presented in Tables 5.1.3 indicate that almost all critical risks at the stages of input, production, post-harvest, and marketing & price were significantly more potential to female, older, less educated/illiterate, socially backward, low income groups, and marginal & small farm groups.

Table 5.1.3: Critical supply chain risks across socio-demographics and farm groups

Supply Chain Stages	Critical Risks	Gender	Age	Education	Social Category	Household Income	Landholdings
Input	High cost of inputs	5.856*	2.594**	5.291*	33.814*	28.755*	26.973*
	Lack of capital	11.648*	1.729	4.674*	41.685*	22.285*	34.792*
	Shortage of inputs	2.792*	2.272	3.899*	22.889*	18.229*	23.053*
	Lack of collateral	0.188	0.882	2.408**	2.207*	1.817	1.851
Production	Weather uncertainty & Climate Change	7.327*	1.650	4.054*	47.178*	30.186*	31.128*
	Lack of technical skills/GAP	8.149*	4.933*	3.942*	48.459*	31.991*	41.936*
	Crop disease/Termites /Insects	6.569*	4.495*	4.355*	41.329*	21.145*	28.866*
	Lack of access to farm technology	3.738**	5.513*	5.729*	21.987*	11.785*	25.566*
Post-harvest	Lack of sorting/ grading	8.702*	3.744*	4.061*	48.746*	31.048*	35.587*
	Lack of storage facility/cold chain	9.244*	2.201	5.350*	45.843*	29.619*	37.360*
	Lack of quality control practices	13.600*	2.832**	5.538*	36.310*	28.606*	34.150*
Marketing & price	Lack of bargaining power	8.537*	4.997*	5.167*	50.080*	32.033*	50.248*
	Market price volatility	9.057*	2.559**	4.208*	39.197*	36.320*	31.340*
	Lack of market information	1.768	3.429*	3.606*	20.929*	19.377*	30.020*
	Exploitation by middlemen	4.943**	3.264*	4.078*	36.341*	21.204*	39.858*
	Inaccessibility of market	3.927**	2.613**	1.242**	10.585*	8.688*	31.340*

*significant at 1% level ** significant at 5% level

Section- B

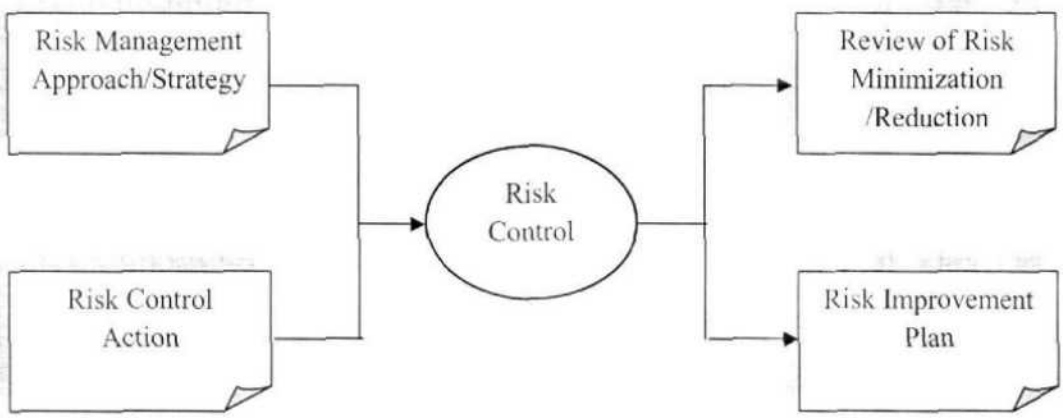
5.2 TREATMENT OF CRITICAL RISKS ACROSS VEGETABLE SUPPLY CHAIN

(Post-Clustering Intervention Assessment)

5.2.1 Risk Control Actions and Adoption of Critical Risk Management Strategies

Risk management is the planned control of risk. The risk evaluation processes which prioritize the unacceptable level of risks/critical risks are required effective control measures put into action to minimize the risks. Risk control is the reactive process of managing potential risks. Figure 5.2.1 depicts that risk control involves specific risk management approach/strategy and execution of risk control actions in order to minimization/reduction of the risk and further plan for risk improvement.

Figure 5.2.1: Risk control framework



Several innovative mechanisms are evolved and practicing at ground level for effective risk control and risk management. Since Independence, Government is continuing to support agriculture sector through risk management policies and programmes and other important mechanisms. Apart from Government, private agencies and NGOs including community organizations are increasingly put effort to organized farmers as an effective approach to empower them for effective risk management.

5.2.1.1 Clustering: An Approach to Effective Risk Management

Risk management is becoming a key issue for farmers and is also receiving significant attention by Government, Private Sector / Agencies and NGOs. Farmers have been also seeking guidance and education on how they can better manage the agricultural risks. Several field level experiments across the countries are going on to find out the effectively approach to counter agricultural risks. Past studies have shown that, in order to gain strength, organizing farmers into group is a powerful tool to educate and empower farmers (Muma, 2002; Goodwin and Schroeder, 1994). When farmers become organized, they find themselves in a better position to deal with agricultural risk through effective control measures. Clustering[11] is an innovative approach to organize farmers into groups, interlink and network them into cluster. This enables to supply of agricultural risk management education and training to the farmers.

On the similar approach, Agricultural Risk Management Agency Pvt. Ltd which is implementing Vegetable Risk Management Project at the selected locations in the state of Uttar Pradesh (India), have organized vegetable farmers in small groups and networked them into cluster. The major steps and activities/tasks performed in the formation of cluster in order to implement the project are presented in Table 5.2.1.1. Each cluster was geographically interconnected with 15 groups and also have active linkages with Government departments (Horticulture Department), Agricultural Universities/KVKs, financial institutions/banks, input suppliers/agencies, wholesale markets, local NGOs and Community Organizations.

The Risk Management agency regularly organize trainings and capacity building programmes to the cluster farmers on vegetable risk management and related aspects, according to farmers need. To provide technical knowledge and awareness, several workshops were organized on the emerging aspects of agriculture such as organic vegetable farming, IPM and Precision Farming. To strengthen the cluster,

[11]There are many definitions pertaining to the concept of clustering that are available in academic literature. This stems from the fact that the concept may be used for a variety of different business structures, applications and categories. The different definitions of clustering are largely based on the categories from which they originatesuch as: national-regional-cross-border clusters, clusters of competence, or industrial or production systems (Carpinetti and Lima, 2009, APEC, 2005, Cortright, 2006).

institutional linkages were established with Krishi Vigyan Kendra (KVKs), Horticulture Department, and Agriculture Department of Universities/local agricultural colleges.

Table 5.2.1.1: Major steps and activities/tasks of the clustering approach

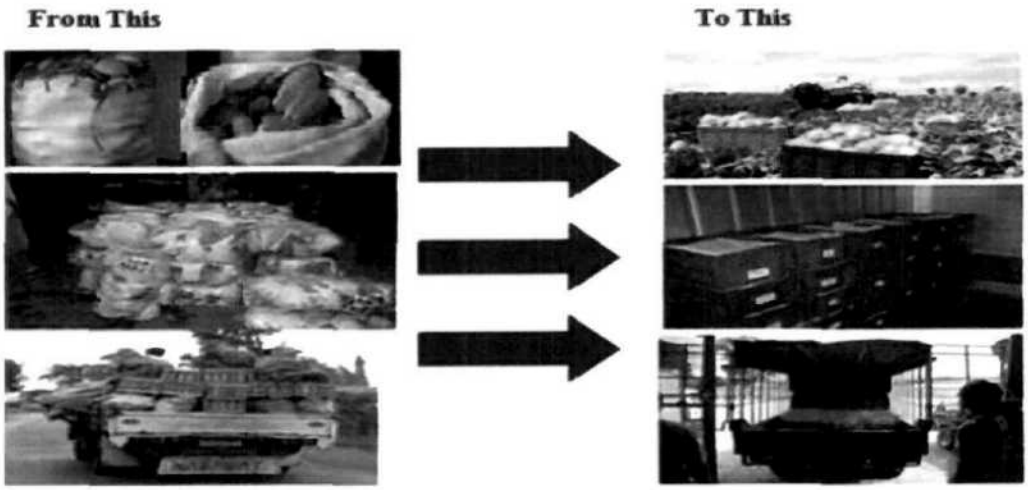
Steps	Activities/Tasks
(1) Site selection, partnership building and formation of Risk Management Working Group (RMWG)	• Identify project site • Establish consortia and develop partnerships with stakeholders: Government (Horticulture Department), local NGOs working on agricultural extension related activities, development organizations, standardized local agribusiness firms and input suppliers/dealers company agents, vegetables farmers • Constituting RMWG with consortia representatives • Convene orientation sessions and planning meetings
(2) Mapping supply chain and assessment of risks	• Assist the RMWG to organize a local research team • Provide training to the research team • Literatures survey and desk appraisal for content development • Develop research questionnaire and pilot testing • Implementation of survey in the project areas • Data coding, entry works and analysis of results • Consolidate findings into a report
(3) Mobilization, group formation and clustering	• Mobilizing farmers and invite them for orientation meeting; and presentation of report • Describing the results of risk involved at various stages of vegetable supply chain • Provide orientation on risk management basics and benefits of organizing into groups • Mobilizing farmers for the formation of group for risk management and identification of group leaders • Clustering of groups, identification of cluster leaders, conduct organizational planning • Cluster formed with cluster leaders • Objectives set to minimize the risks
(4) Cluster strengthening and capacity building (Training and technical support)	• Ensure that group and cluster leaders convene regular meetings • Facilitate capacity building: risk management trainings, team building activities, cluster cross-visits, exposure trips, reflection sessions etc. • Financial inclusion through institutional credit linkages • Removal of intermediaries and efficient market linkages • Establish collection centers nearby the vegetable production site • Transport and logistics support and direct linkages with wholesale market • Collaboration with Agricultural Universities /KVKs /Horticulture Departments/Marketing Agencies • Plan and Risk scheduling[12] • Risk Management Assignments (who is responsible for what) • Risk monitoring and review
(5) Monitoring cluster performance and review	• Regular performance report to individual groups and clusters • Track and report risk status • Implement suggestions/recommendations for further improvements

Exposure visits to selected cluster farmers were also organized by the consortia to provide them practical touch. Irrigation water user groups were also formed to ensure judicial and proper irrigation. Financial inclusion of almost all the cluster farmers was

[12] Risk scheduling is the process of integrating risk management plan tasks into a project schedule.

ensured from the active support of local rural banks. Linkages with various agribusiness companies/agencies/ local dealers dealing in farm input supply and services were established to facilitate collective purchase of quality inputs and access of farm services. Collective sell of vegetables were also facilitated by the Consortia (Figure 5.2.1.1a). Also, regular health checkups camp for cluster farmers were organized by the agency.

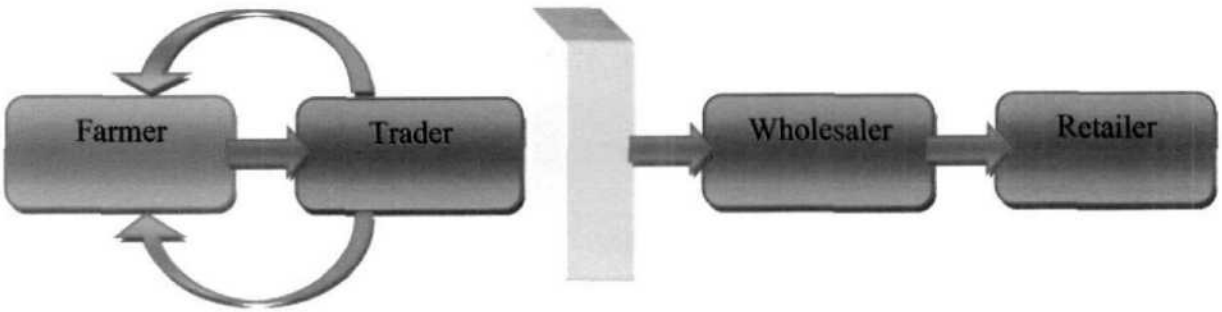
Figure 5.2.1.1a: Collective sale of vegetables for economies of scale



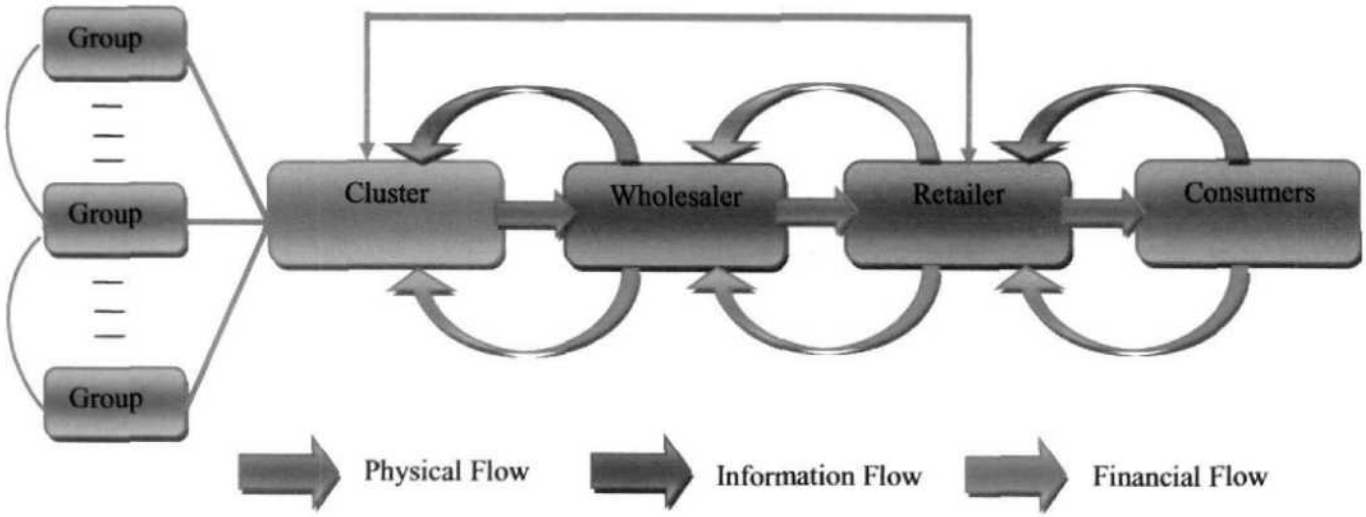
Clustering strategy enabled the cluster farmers to access the wholesale and retail market which earlier was out of reach to them due to lack of economies of scale, poor quality of produce, lack of sorting & grading, and poor packaging & labelling (Figure 5.2.1.1b).

Figure 5.2.1.1b: Market access - With and without cluster

Before....



With cluster and capacity building & risk management



5.2.1.2 Adoption of Critical Risk Control Strategies Across Supply Chain

The essence of managing agricultural risk is making good decisions and choosing best strategy among alternatives to reduce the impact of potential risks. The understanding of the farmers' reaction to risk through their selection and adoption of risk management strategies is vital to policy makers, development agencies, Government departments, and other supply chain stakeholders in order to take effective actions to improve the farm businesses. In the present study, the various critical risk management strategies adopted by farmers in order to counter the vegetable supply chain risks are presented below.

5.2.1.2.1 Critical Input Risk Management Strategies

Table 5.2.1.2.1 presents the various strategies adopted by the farmers to manage the four critical input risks. There was significant difference between cluster and non-cluster farmers in the critical input risk management adoption behaviors. *Collective buying of inputs* was considered the most important risk management strategy adopted by majority of cluster farmers only. While non-cluster members preferred to *buy when input prices* were relatively low as compared to planting season. *Use of own stored seed* was also an important input source used by about quarter of farmers from both the

groups. This finding is similar to NSSO[13] results, which indicate that traditional farm saved seed still dominates the seed basket. In order to minimize the capital risk as critical one, majority of cluster farmers preferred to *borrowed institutional credit* followed by *extensive farming*. The diversification of economic activities towards *non-farm* and *allied activities* were major counter strategies adopted by non-cluster farmers. Previous studies also resulted that diversification was frequently used risk management strategy, a self-insuring tool used by farmers to protect against risk (Gulati et al, 2007; Joshi et al, 2006).

Table 5.2.1.2.1: Critical input risk management strategies

	Cluster		Non-Cluster		Chi-square Statistics
	N	%	*N*	%	
Strategies for managing high cost of inputs					
Buying when prices are relatively low	4	2.3	35	22.2	$\chi^2 = 197.705$ $p=0.000$
Collective buying	81	47.4	0	0.0	
Use of own stored seed	46	26.9	39	24.7	
Extensive farming	30	17.5	0	0.0	
Contract arrangements	0	0.0	17	10.8	
Profit sharing with dealer for inputs on credit	0	0.0	25	15.8	
Do nothing	10	5.8	42	26.6	
Strategies for capital risk management					
Borrow institutional farm credit	89	57.8	12	9.3	$\chi^2 = 160.967$ $p=0.000$
Contract farming	0	0.0	17	13.2	
Extensive farming	40	26.0	12	9.3	
Diversification towards allied activities	0	0.0	22	17.1	
Non-farm activity	0	0.0	32	24.8	
Selling-out land	0	0.0	2	1.6	
Do nothing	0	0.0	14	10.9	
Others	25	16.2	18	14.0	
Strategies for managing shortage of quality input					
Prior purchase	4	2.4	33	22.0	$\chi^2 = 190.54$ $p=0.000$
Liaisoning with input dealer	108	64.3	18	12.0	
Buy inferior quality input from open market	0	0.0	44	29.3	
Sharing with fellow farmers	23	13.7	21	14.0	
Diversification towards ag. allied activities	0	0.0	8	5.3	
Do nothing	0	0.0	24	16.0	
Others	33	19.6	2	1.3	
Strategies for collateral arrangements					
Partnering with prime bank customers	26	15.5	9	6.0	$\chi^2 = 251.365$ $p=0.000$
Mortgaging	0	0.0	40	26.7	
Group formation and linkages with bank	104	61.9	0	0.0	
Group formation and linkages with MFI	11	6.5	0	0.0	
Do nothing	27	16.1	101	67.3	

[13]NSS 59[th]Round Report (No. 496& 499)

Shortage of inputs and lack of timely availability of input were the most common sources of risk to farmers in India (Ali and Nath, 2008). A high proportion of the cluster farmers (64%) reported to have *liaisoning with input dealer* to ensure timely supply of necessary inputs. While non-cluster farmers adopted strategies were *buy inferior quality input from open market* and *prior purchase of inputs*. For collateral arrangements, the cluster farmers were well *organized into groups* and gone for *bank* linkages. Majority of non-cluster farmers were helpless and some 26.7 percent believed in mortgaging for collateral arrangements. Similar observations from ground level studies obtained which indicate that unorganized farmers were more vulnerable to access farm inputs as compared to organized one (Deshingkar et al, 2003; Bergfjord 2009).

5.2.1.2.2 Critical Production Risk Management Strategies

Risk management is largely attributed to production risk management. Table 5.2.1.2.2 demonstrate that *regular accesses to weather forecast information* and *new cropping pattern* were useful strategies adapted by cluster farmers to respond the critical risk of weather uncertainty & climate change. While due to lack of education and information majority of non-cluster farmers were helpless to counter this. Importantly, some 21 percent were accessing *weather forecast information* from relevant sources.

A variety of preventive strategies for crop disease and termites/insects were adopted by both cluster & non-cluster farmers which includes *seeking expert/agricultural scientist's advice, use of IPM, and application of clean irrigation water, crop rotation, use of hybrid/GM seeds & pesticides/insecticides* and *field sanitation*. Some 20 percent non-cluster farmers reported to *do nothing* to prevent the same. Learning advanced technical skills and good agricultural practices (GAP) always helping out farmers in practicing commercial agriculture (Caswell et al., 2001; Galloway and Mochrie, 2005). About a quarter of cluster farmers reported to participate in *field demonstration* and *farm visits* organized by the NGOs/agencies. Learnings from *TV/Radio programmes* on production risk management also reported by some farmers from both the groups. About 45 percent of the cluster farmers were also advancing their technical skills from fellow farmers, commercial vegetable growers, and farmers filed school (FFS). Importantly, more than half of the non-cluster farmers were not involved in any skill up-gradation programmes on agricultural production.

Table 5.2.1.2.2: Critical production risk management strategies

	Cluster		Non-Cluster		Chi-square Statistics
	N	%	*N*	%	
Strategies for managing weather uncertainty & Climate Change					
Regular access to weather forecast info.	85	49.7	33	20.9	$\chi^2 = 145.326$ $p=0.000$
Crop insurance	12	7.0	5	3.2	
Adopt new cropping pattern	64	37.4	11	7.0	
Do nothing	10	5.8	109	69.0	
Strategies for GAP & technical skills					
Demonstration & farm visits organized by NGOs/Private agencies	42	25.0	8	5.3	$\chi^2 = 92.359$ $p=0.000$
Demonstration & farm visits organized by KVKs/Ag. University	2	1.2	12	8.0	
TV/Radio programmes on agriculture	29	17.3	19	12.7	
Do nothing	18	10.7	81	54.0	
Others	77	45.8	30	20.0	
Strategies for minimizing crop disease & attack of termites/insects					
Use of hybrid/GM seeds	17	9.9	32	20.3	$\chi^2 = 96.782$ $p=0.000$
Use of pesticides/insecticides	15	8.8	43	27.2	
Crop rotation	17	9.9	11	7.0	
Field sanitation	14	8.2	7	4.4	
Use of clean irrigation water	20	11.7	10	6.3	
Expert/Ag-scientist's advice	56	32.7	10	6.3	
Use of IPM	32	18.7	13	8.2	
Do nothing	0	0.0	32	20.3	
Strategies to access farm technology					
Collective buying/access	49	29.2	0	0.0	$\chi^2 = 92.359$ $p=0.000$
Seek Govt. support to enable access farm tech	9	5.4	40	26.7	
Approach agricultural universities/KVKs etc.	2	1.2	12	8.0	
Use of mass media & E-junctions	29	17.3	19	12.7	
Attend training programmes/Camp organized by NGOs/Private agencies	79	47.0	4	2.7	
Do nothing	0	0.0	75	50.0	

Technology plays crucial role in increase productivity of agriculture. However, individual and unorganized farmers always find it is difficult purchase/access of farm technology due to lack of capital and high cost of maintenance. Cluster farmers preferred toatt*end training programmes/Camp organized* by the consortia in cooperation with manufacturing firms where cluster farmers were given discount on buying of farm equipments. *Collective buying* of farm equipments was also promoted and supported by the consortia. Some cluster farmers also found the way to access technology through *mass media & E-junctions*. Half of the non-cluster farmers were helpless to purchase/access farm technology and some 26.7 percent farmers were seeking *Government support* to enable the access farm technology.

5.2.1.2.3 Critical Post-harvest Risk Management Strategies

Post harvest is the most important value addition stage where more than 75% value addition activities were performed. Also, this stage is known for huge produce losses in the country due to infrastructural bottleneck and limited processing (only 2.2% of total production). Table 5.2.1.2.3 reports the risk management strategies adopted by the farmers to counter critical post-harvest risks and also for value addition. A significant majority (93%) of cluster farmers and 16.5 percent non-cluster farmers reported to perform *sorting & grading* value addition activity. Remaining majority (83.5%) of non-cluster farmers reported to *do nothing*.

Vegetables are one of the most perishable crops which require it urgent reach to the market/processing centre/cold storage. Considering the perishable nature of the produce, a majority (64.9%) of cluster farmers and some (8.9%) non-cluster farmers preferred to *sale instant after harvest* it. More than 71 percent non-cluster farmers reported to *do nothing*. More than half of the cluster farmers were also reported to attend trainings on quality control and standards measures/practices. Moreover, *Good Agricultural Practices (GAP)* across farm operations was also performed by majority of cluster (43.3%) and some (8.9%) non-cluster farmers. Majority of non-cluster farmers were not participating in quality control practices.

Table 5.2.1.2.3: Critical post-harvest risk management strategies

	Cluster		Non-Cluster		Chi-square Statistics
	N	*%*	*N*	*%*	
Strategies for sorting/grading					
Do sorting & grading of produce	159	93.0	26	16.5	$\chi^2 = 195.408$ $p=0.000$
Do nothing	12	7.0	132	83.5	
Strategies for storage of food produce					
Sale instant after harvest	111	64.9	14	8.9	$\chi^2 = 231.277$ $p=0.000$
Store at public/private cold storage	13	7.6	16	10.1	
Marketing contracts	0	0.0	15	9.5	
Do nothing	5	2.9	113	71.5	
Others	42	24.6	0	0.0	
Strategies for quality control practices					
Attended training on quality control measures	88	51.5	0	0.0	$\chi^2 = 246.893$ $p=0.000$
Follow GAP across farm operations	74	43.3	14	8.9	
Do nothing	9	5.3	143	91.1	

5.2.1.2.4 *Critical Marketing and Price Risk Management Strategies*

Managing critical marketing risks are crucial to save farmers from the exploitation by middlemen and also to provide them reasonable price of their produce. Table 5.2.1.2.4 presents major strategies adapted by the farmers to manage critical marketing and price risks. The clustering strategy enabled for economies of scale and *collective bargaining* which helped farmers to reach out their produce directly to the *wholesale markets / processors / retailers*. Majority of the non-cluster farmers were helpless to counter the critical marketing and price risks. However, market information was accessed by both the groups from the sources of social network including fellow farmers and mass media/ICT & mobile phones.

Table 5.2.1.2.4: Critical marketing and price risk management strategies

	Cluster		Non-Cluster		Chi-square Statistics
	N	%	*N*	%	
Strategies to increase bargaining power					
Collective bargaining	165	96.5	0	0.0	$\chi^2 = 305.842$ $p=0.000$
Do nothing	6	3.5	158	100.0	
Strategies for managing market price volatility					
Marketing contracts	0	0.0	19	12.1	$\chi^2 = 239.000$ $p=0.000$
Do nothing	0	0.0	110	70.0	
Others	171	100.0	28	17.9	
Strategies to access market information					
Use of mobile/phone	32	18.7	45	28.5	$\chi^2 = 4.569$ $p=0.000$
Use of mass media /ICTs (radio/TV)	40	23.4	34	21.5	
Use of social network	46	26.9	39	24.7	
Access from fellow farmers	53	31.0	40	25.3	
Strategies for preventing exploitation by middlemen& market access					
Marketing contracts	0	0.0	19	12.1	$\chi^2 = 266.036$ $p=0.000$
Collectively sell at organized markets/ wholesale markets/ processors/retailers	171	100.0	17	10.8	
Do nothing	0	0.0	121	77.1	

5.2.2 Socio-Demographic Factors Affecting Management of Critical Supply Chain Risks

Table 5.2.2 presents the investigation results of analysis of variance (ANOVA) of various demographic and farm related factors affecting the management of critical risks across supply chain. The findings clearly indicate that many socio-economic factors viz. gender, age and education do not play any significant role in the management of critical supply chain risks. However, social category plays a significant role in the management of some of the critical supply chain risks. As the farmers belong to OBC

category were more effective in the management of capital requirements and shortage of inputs; as compared to other social groups. The General category farmers were impressive in the management of market price volatility and to the access of farm technology. The household income and landholdings were found to be significant factors positively influencing the management of critical risks across the supply chain. Large farmers and/or those belonging to high income groups were significantly performing well in management of critical risks across supply chain.

Table 5.2.2: Factors affecting management of critical risks across supply chain

Supply chain stages	Critical Risks	Gender	Age	Education	Social Category	Household Income	Landholdings
Input	High cost of inputs	0.000	0.696	0.062	2.480	8.441*	11.150*
	Lack of capital	1.296	1.060	0.413	3.081**	6.617*	14.267*
	Shortage of quality inputs	0.542	1.274	0.615	1.271	7.082*	15.145*
	Lack of collateral	0.458	0.240	1.013	3.986**	1.120	33.396*
Production	Weather uncertainty & Climate Change	0.130	0.228	1.696	1.670	6.352*	11.984*
	Lack of technical skills & GAP	0.195	0.724	0.506	1.847	9.105*	14.049*
	Crop disease & Termites /insects	0.234	1.534	0.038	1.486	7.399*	12.209*
	Lack of access to farm technology	1.227	0.015	0.372	3.442**	7.607*	21.715*
Post-harvest risks	Lack of sorting/ grading	0.235	0.637	0.929	1.010	5.335*	15.791*
	Lack of storage facility / cold chain	0.409	0.370	0.385	1.429	8.057*	17.871*
	Lack of quality control practices	0.105	1.196	0.995	2.887	7.132*	8.591*
Marketing & price	Lack of bargaining power	0.721	0.414	0.461	2.981	6.845*	9.739*
	Market price volatility	0.782	0.196	0.480	4.397*	9.143*	19.372*
	Lack of market information	0.071	0.390	1.004	1.453	9.265*	9.220*
	Exploitation by middlemen	0.000	0.295	0.242	1.083	5.597*	9.993*
	Inaccessibility of market	3.583	0.736	1.427	2.325	2.835**	20.130*

*significant at 1% level ** significant at 5% level

5.2.3 Comparative Review of Risk Levels Between Cluster & Non-Cluster

Risk Management is a continuous improvement process. Effective risk management requires review of impact assessment to ensure that risks are effectively identified and that appropriate controls and responses are in place. Under the present study, for the

cluster farm groups, the interventions to manage critical input risks were made by Risk Management Agency Pvt. Ltd whereas no special interventions were made for non-cluster participants. For the review of impact assessment of the risk control plans / strategies, the comparison of average RPN estimates between cluster and non-cluster farm groups in the post-intervention period may provide exiting results. Such review process provides assurance that there are appropriate risk controls measures are in place. Also, the review process is of paramount importance which involves acquiring new information and determining appropriate risk reduction measures according to changing circumstances.

5.2.3. 1 Comparative Review of Input Risks

Table 5.2.3.1 reveals the comparative review of comparative input risk levels between cluster and non-cluster groups. It clearly shows that there were significant differences between cluster and non-cluster producers in RPN estimates of all the sources of input risk with comparatively low value of RPN value of cluster participants. Importantly, the strategies for critical input risk management have also fuelled to decrease the non-critical input risks by cluster groups.

Table 5.2.3.1: Comparative review of input risk levels

Sources of input risk	**RPN**			**F-Statistics**	**Sig.**
	Total	*Cluster*	*Non-Cluster*		
High cost of inputs	406	269	679	715.838	0.000
Lack of capital	406	268	682	872.229	0.000
Shortage of quality inputs	399	253	690	983.242	0.000
Timely unavailability	153	126	207	94.619	0.000
Lack of collateral	151	91	272	557.340	0.000
Lack of financial inclusion	135	96	215	137.115	0.000
High interest rate for loans	117	92	167	142.228	0.000
Poor quality	96	62	164	393.883	0.000

5.2.3. 2 Comparative Review of Production Risks

Table 5.2.3.2 displays comparative review of production risk levels between cluster and non-cluster groups. Except the natural calamities such as hail/ tempest, drought and flood, the cluster members were significantly managed all remaining critical production risk as indicated by the low RPN estimates as compared to the non-cluster. Also, the strategies adopted by cluster farmers to manage the critical production risks were effective and proven to be fruitful for non-critical risks encompassing production risk, especially for lack of irrigation and illness/disability. The unorganized non-cluster

farmers seems to be helpless to manage the production risk as there was no remarkable reduction in RPN estimates of production risks.

Table 5.2.3.2: Comparative review of production risk levels

Sources of production risk	RPN			F-Statistics	Sig.
	Total	*Cluster*	*Non-Cluster*		
Crop disease & Termites/insects	422	262	742	799.304	0.000
Lack of technical skills & knowledge of GAP	401	264	674	767.131	0.000
Weather uncertainty & Climate Change	396	260	668	765.534	0.000
Hail/ tempest	127	125	132	1.799	0.181
Lack of irrigation	102	89	128	34.247	0.000
Lack of access to farm technology	96	40	209	605.660	0.000
Drought	65	66	63	0.768	0.382
Flood	63	64	63	0.223	0.637
Illness/Injury/disability/ death	51	26	101	459.462	0.000
Shortage of reliable labour	39	28	63	267.179	0.000

5.2.3. 3 Comparative Review of Post-Harvest Risks

The comparative review of post-harvest risk levels between cluster and non-cluster groups are presented in Table 5.2.3.3. The F-statistics shows that there were significant differences between cluster and non-cluster farm groups in post-harvest risk management with better risk management by the cluster members. As indicated by comparatively low RPN estimates by cluster members, they were able to counter the post-harvest risks effectively through the learning and adoption of better post-harvest practices than non-cluster.

Table 5.2.3.3: Comparative review of post-harvest risk levels

Sources of post-harvest risk	RPN			F-Statistics	Sig.
	Total	*Cluster*	*Non-Cluster*		
Lack of sorting/grading	433	245	810	1172.309	0.000
Lack of storage facility/cold chain	417	256	740	1048.126	0.000
Lack of quality control practices	393	260	659	810.064	0.000
Poor packaging	100	64	172	386.499	0.000
Lack of labelling	85	64	127	261.811	0.000
Improper product handling	58	41	92	111.813	0.000
Lack of branding	32	26	46	65.293	0.000

5.2.3. 4 Comparative Review of Marketing & Price Risks

Table 5.2.3.4 presents the comparative review of marketing & price risk levels between cluster and non-cluster groups. Like the earlier stages of supply chain (input, production

&post-harvest), the cluster members were significant more capable to effectively manage the marketing & price risks as compared to counter-part (non-cluster).

Table 5.2.3.4: Comparative review of marketing & price risk levels

Sources of marketing & price risk	RPN			F-Statistics	Sig.
	Total	*Cluster*	*Non-Cluster*		
Market price volatility	444	264	804	1226.718	0.000
Exploitation by middlemen	400	272	657	631.634	0.000
Lack of bargaining power	400	265	670	719.783	0.000
Lack of market information	399	256	683	815.310	0.000
Low market demand of produce	272	272	270	0.035	0.852
Lack of transportation facility	250	163	424	675.595	0.000
Lack of discriminatory pricing for quality/graded produce	65	44	107	103.931	0.000
Inaccessibility of market	59	27	124	680.189	0.000
Difficulties at market place	35	29	46	41.546	0.000

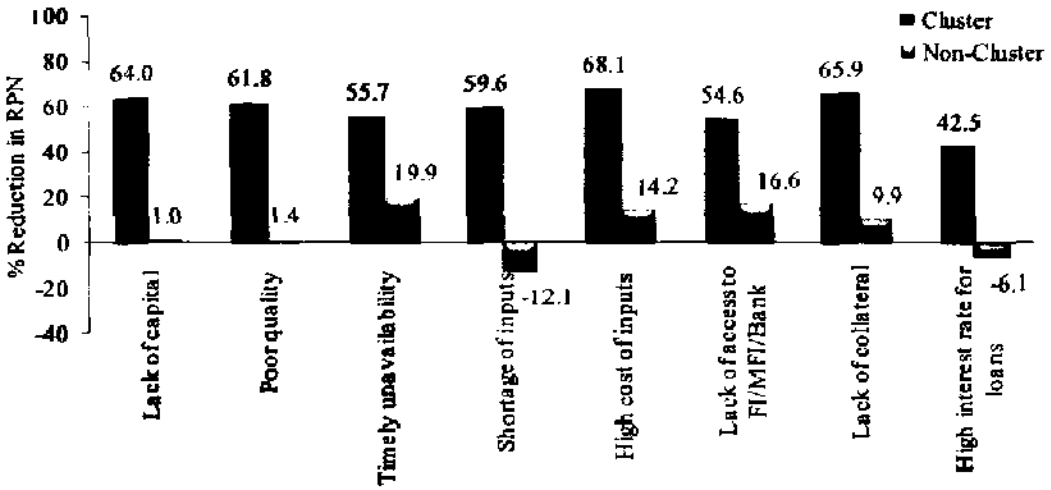
The above risk performance by cluster members explicitly demarcates the very fact that the capacity building interventions made by the Risk Management Agency Pvt. Ltd to manage the critical risks across the vegetable supply chain were noteworthy enough to mark the difference between the business as usual and with focussed interventions.

5.2.4 Comparative Review of Risk Reduction between Cluster & Non-Cluster

5.2.4.1 Comparative Reduction of Input Risk

Figure 5.2.4.1 reveals the comparative percentage reduction in RPN for various input risks within cluster & non-cluster. It is clear that the percentage reduction in RPN for all inputs risks by cluster farmers was much higher than its counterpart and there exists a sea difference between these two groups. The peak 68.1 percent reduction in RPN for *high cost of inputs* was observed for cluster farmers. The performance explicitly demarcates the very fact that the capacity building interventions made by the Risk Management Agency Pvt. Ltd to manage the input risk were noteworthy enough to mark the difference between the businesses as usual and with focussed interventions. Importantly, the strategies for critical input risk management have also fuelled to decrease the non-critical input risks. As RPN values for almost all non-critical input risks such as *poor quality of inputs, lack of access of financial institutions* and *high interest rate for loans* were also reduced for cluster members.

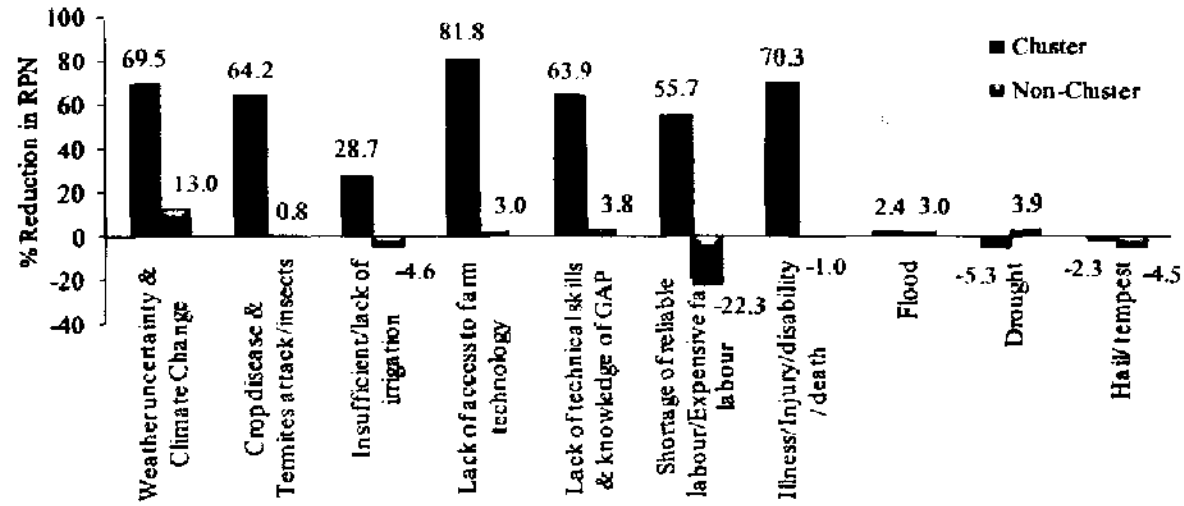
Figure 5.2.4.1: Comparative percentage reduction of input risks



5.2.4.2 Comparative Reduction of Production Risk

Figure 5.2.4.2 displays comparative percentage reduction in RPN for production risks within cluster & non-cluster. Estimate indicates that the strategies adopted by cluster farmers to manage the critical production risks were effective and proved to be fruitful even for non-critical risks encompassing production risk, especially for lack of irrigation and illness/disability. The highest 81.8 percent reduction in RPN for *lack of access to farm technology* was observed for cluster farmers. However, negligible/no difference in RPN values could be noticed in terms of natural calamities such as flood, drought, hail etc. The unorganized non-cluster farmers seems to be helpless to manage the production risk as there was no remarkable reduction in RPN values of their counter interventioos.

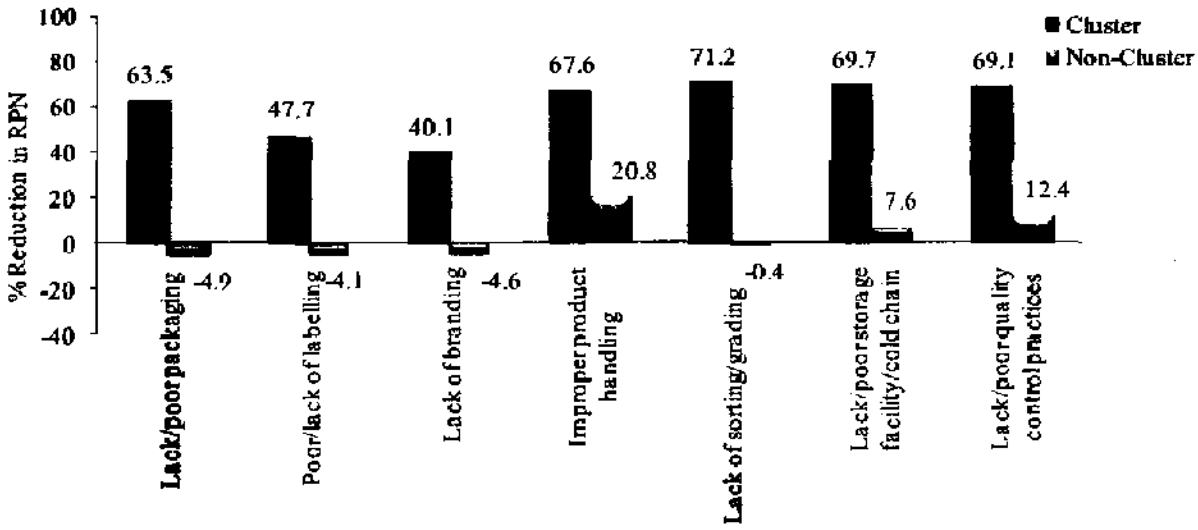
Figure 5.2.4.2: Comparative percentage reduction of production risks



5.2.4.3 Comparative Reduction of Post-Harvest Risk

Figure 5.2.4.3 presents comparative percentage reduction in RPN for post harvest risks within cluster & non-cluster. The performance for post-harvest risk reduction (in terms of RPN values) of cluster farmers is for better than non-cluster. The highest percentage reduction in RPN for post harvest risk was noticed for cluster farmers to lack of sorting/ grading followed by lack of storage facility and poor quality control practices. A maximum 20.8 percent reduction in RPN for *improper product handling* was observed for non-cluster farmers.

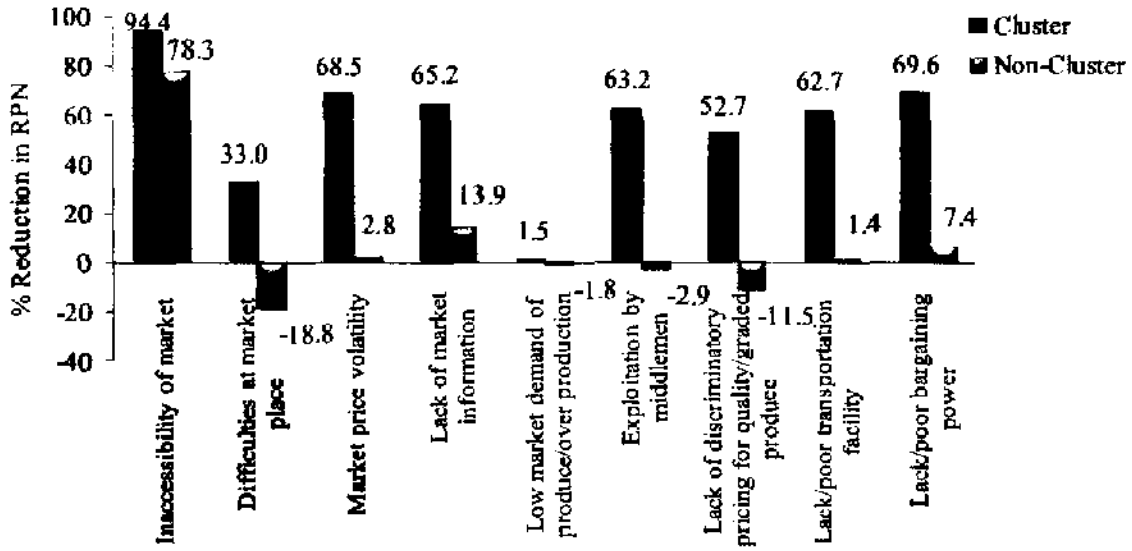
Figure 5.2.4.3: Comparative percentage reduction of post-harvest risks



5.2.4.4 Comparative Reduction of Marketing & Price Risks

Figure 5.2.4.4 portraits the comparative performance of marketing and price risk reduction within cluster & non-cluster. The percentage reduction in RPN values for all five critical risks (inaccessibility of market, exploitation by middlemen, lack of market information, lack of bargaining power, and market price volatility) indicate that the performance of cluster farmers were for better than non-cluster. However, the non-cluster farmers were performed well in decreasing the risk of *market inaccessibility.* Improving rural infrastructures such as road and bridges due to Government interventions through MGNREGA and Pradhan Mantri Gram Sadak Yojna (PMGSY) could be contributing factors to improve farmer - market linkages.

Figure 5.2.4.4: Comparative percentage reduction of marketing & price risks



Above review analysis of risk reduction within cluster and non-cluster again confirms that clustering approach enabled the cluster members to effectively management of both critical and non-critical risk across the vegetable supply chain. In contrast, the non-cluster farmers through traditional risk management approach and strategies were not effective to manage both critical and non-critical risk across the chain, when compared with cluster.

Chapter 6

CONCLUSIONS, IMPLICATIONS AND SUGGESTIONS

This chapter summarizes the relevant findings (based on statistical evidence) generated throughout the research process and concludes with their implications. For further details and the underlying facts and evidences the concerned chapters may be referred. The study also explains recommendations derived from the findings and observations. Possible directions for further researches are also indicated.

6.1 Summary of Conclusions

The management of agricultural risks in developing countries is one of the greatest challenges of the 21st century. This research was broadly motivated to address the challenges of risk management in agriculture and agricultural supply chain in Indian context with special reference to the vegetable value chain.

Managing agricultural risk in emerging economy like India which is passing through a transition and structural changes is a very difficult task. Major conclusion drawn from the examination of transition and structural shift in Indian agriculture (Chapter 1) shows that there is a clear shift in agricultural production from traditional foodgrains to high-value and 'more dynamic' agricultural commodities such as fruits and vegetables, milk and milk products, meat, fish, and processed food products. High value crops are costly to produce and risky to manage besides being more market dependent and highly perishable. Studies have suggested that, cultivation of high value horticultural crops such as fruits and vegetables are capital intensive hence more risky particularly to small-scale farmers. However, it can potentially increase farm incomes and contribute to employment if an effective and integrated risk management approach to be adopted. Therefore, horticulture-led agriculture growth has multiplier effects and has important implications for food & nutritional security, and poverty reduction in the country. As suggested by findings that despite relatively small share of horticulture crops in arable land use, the contribution of value that horticultural production adds to

total agriculture in the country is impressive. High value vegetables are significant and major contributor to total horticultural production in India. Considered as a vegetable basket of the world, India is the second largest prnducer of vegetables in the world which accounts for about more than 15 percent of the world's production of vegetables. Out of states, Uttar Pradesh was estimated as one of the largest contributor to national production with 16 percent share from about 13 percent area under vegetable cultivation.

The nation is alsn experiencing an increasing trend in organized retailing in food & grocery, rural retailing & food services market. The organized food and grocery retail market is estimated at US$ 9 billion in 2011 and is expected to grow to US$ 34 billion by 2016, at CAGR of 30%. Likewise, organized rural retail and food service markets are projected to multi-fold grow in near future. However, the future growth of organized retail industry to a large extent depends on agricultural supply chain. So, efforts must be made to manage potential/critical agricultural risks for efficient and effective performance of the supply chain.

There are multiple and simultaneous sources of risks faced by farmers at all the stages of agricultural supply chain. Literature on agricultural risks (Chapter 2) has identified various sources of risk in across the vegetable supply chain that has negative impact on the supply chain performance. Considering the occurrence of risk across the chain, the sources of risk have been classified into categories such as input, production, post-harvest and price & marketing. Conclusion drawn from literature survey on agricultural risk management can be summarized that the agrarian communities have traditionally employed various formal and informal strategies to manage agricultural risk, either before (Ex-ante) or after the effects of risk (Ex-post). Ex-ante strategies can reduce risk (by eradicating pests or farm management, for example) or limit exposure to risk (grow pest-resistant varieties or diversify into crops unaffected by those pests, improved information system). Risk can also be mitigated using Ex-ante strategies by huying insurance or through other responses to expected losses such as self-insurance (precautionary savings) or reliance on social networks (for access to community savings, for example). Ex–post strategies which are adopted to cope with losses from risks that have already occurred include selling of assets, seeking temporary employment, off-farm work and migration. Governments provides supports to the affected families through formal safety nets such as subsidies, waiver (cancellation) of

crop loans, social assistance & social funds, rural public works programs, and food aid to help farms and firms (and their laborers) cope with negative impacts of risky events.

The study has identified a research gap in the agricultural risk management literature (Chapter 3). Currently, traditional risk management process is fragmented, ad-hoc, non-continuous and narrow focused which does not integrate small scale farmers in the supply chain. This research addressed this research gap and contributes as new body of literature. This study was undertaken with broad objective of developing an integrated framework for the systematic management of potential/ critical risks in agricultural supply chain with special reference to upstream vegetable supply chain. The framework provides a systematic way of risk management in an integrated, continuous, and broadly focused approach.

This research used both secondary and primary data and adopted appropriate methods to conduct this study (Chapter 4). The secondary data largely used to show the ongoing transition and structural shift towards high value agriculture. While the primary data was employed to investigate the integrated framework of risk management, this study justified the use of Failure Modes and Effects Analysis (FMEA) considering its 3D approach to assess the risk on dimensions of severity (S), occurrence (O) and detection (D) probabilities. Pareto Analysis was also attempted and it was found to be better alternative of Risk Matrix to prioritize the potential risks. The Ishikawa diagram greatly helped to structure the risk analysis process as it represents the potential risk ranges at various stage of the supply chain.

Managing all the risks is virtually impossible. Hence, this study focused on identifying the potential risks at all the stages of the supply chain. Conclusion drawn from risk assessment and prioritization (Chapter 5: Section-A) indicate that out of 34 listed risks in vegetable supply chain, Pareto Analysis has identified a total 16 risks as of high potential/critical. Ishikawa diagram exhibited the disruptive ranges of potential/critical risk at all the stages of vegetable supply chain. Analysis also resulted that almost all the identified potential/critical risks of vegetable supply chain (at the stages of input, production, post-harvest, and marketing & price) were significantly more potential to female, older, illiterate/less educated, socially backward, low income groups, and small-scale farm groups.

An integrated approach to risk management in supply chain facilitates active participation of all the stakeholders, increase social networks, promotes learning, offers institutional and credit support, optimum use of limited resources, promotes quality improvements, increases returns to scale/economies of scale, high returns on investment, promotes innovation and continuous improvements. In the present study, clustering strategy was adopted as an integrated approach to risk management in vegetable supply chain. The Risk Management Agency Pvt. Ltd., the project implementation agency, which have organized the vegetable growers into small groups and networked them into cluster. The agency have formed consortia with Krishi Vigyan Kendra (KVKs), horticulture and agriculture department of universities/local agricultural colleges, Rural Banks, agribusiness firms, farm input dealers, food & rural retailers, NGOs and community based organizations (CBOs) to extend all possible supports to the cluster for effective risk management in vegetable supply chain. The consortia actively involved in organizing exposure visits to cluster farmers, capacity building programmes, technical assistance, financial inclusion of them in formal financial system, formation of irrigation water user groups, facilitation of collective purchase of quality farm inputs & collective sell, collective access of farm services. Importantly, the consortia also extended the social services to the cluster members such as regular health checkups and literacy camp for the farmers & their spouse.

Conclusions drawn from findings (Chapter 5: Section-B) indicate that the cluster famers were significantly and effectively managed the potential/critical risks at all the stages of the supply chain as compared to non-cluster. Importantly, the risk management strategies adopted by cluster farmers for critical risk management have also fuelled to decrease the non-critical risks. In contrast, the non-cluster farmers through traditional risk management approach and control strategies were not effective to manage both critical and non-critical risks in the supply chain. The results generated from findings indicate that some socio-economic factors viz. gender, age and education do not play any significant role in the management of critical supply chain risks. Whereas, socially backward, large farmers and those belonging to high income groups were significantly performing well in management of critical risks in the supply chain.

In conclusion, the research study has been successful in achieving its objectives. The proposed framework of risk management in agricultural supply chain management was researched and concluded to be a scientific, integrated and continuous. This study

has great managerial and policy implications to integrate small-scale farmers into high value chain, enabling the smallholders to remain competitive, synergic institutional arrangements of public and private including NGOs & CBOs, optimum use of limited resources, quality improvements, economies of scale, and linking farmers with emerging global food retail chains.

6.2 Recommendations

The study demonstrated the effectiveness of integrated approach of systematic risk management in agricultural supply chain. The following recommendations were derived from the findings of this research study:

(1) Considering the success of the vegetables cluster in managing risks across the supply chain, clustering may be adopted as an important strategy for the development of farm-entrepreneurship in the country

(2) The integrated supply chain risk management should be considered as an integral strategy for the promotion and development of crop enterprises particularly for commercial crops.

(3) An integrated supply chain risk management planning must consider institutional component, methodological component, operational component. producers review component, environment and climate component.

(4) An integrated supply chain risk management should essentially involve a systematic process of risk identification, assessment, prioritization, risk treatment, risk monitoring and review of risk.

(5) The institutional consortia/ participation (Public-Private-NGOs-CBOs-Farmers) to cover and address all possible sources of agricultural risk should be an integral part of an integrated supply chain risk management framework with clearly defined role of all the stakeholders.

(6) Primary attention should specifically be devoted to addressing risks categorized as 'critical/ highly potential'. The 'critical/potential' risks should be identified at all

the stages of the agricultural supply chain. The potential risks may be identified considering all the three dimensions of risk viz. probabilities of occurrence, severity and detection.

(7) Priority for the facilitation of potential risk management might be given to smallholder, poor farmers by organizing them into groups, capacity building, skill upgradation, technology transfer, bank linkages and clustering.

(8) Training and capacity building (awareness raising, information, knowledge and skills) should be a regular activity to strengthen the capacity of farmers to deal with potential risks. The institutional linkages for financial arrangements and for financial inclusion and upgrade technical skills and other social benefits should be essential for all producers.

(9) The effort shall be made to sustain the cluster through environmentally sustainable cultivation technologies, sustainable market access, wastage minimization, primary processing and value addition, logistics and transportation, infrastructural support, institutional linkages, farm entrepreneurship and leadership.

(10) Initial attention should be given to possible ex-ante measures to manage risks, although in some circumstances assessments will be conducted during/after adverse 'shocks' and attention will certainly be needed on workable and effective coping strategies.

(11) Attention may be given to both formal and informal risk management options including indigenous knowledge of risk management depending upon its effectiveness in the prevailing circumstances. However, preference should be given to adopt formal mechanisms of potential risk management.

(12) There is strong need for the provision of customized, accurate, timely, consistent, and valuable information and market intelligence to the producers. Increased interdisciplinary collaboration between meteorologists, agronomists, and local agricultural institutions (KVKs/Universities) can improve the quality of information which may optimize farming decisions relative to the agricultural risks and uncertainties.

6.3 Direction for Future Research

As this study is limited to a specific crop (vegetables), it will be interesting to investigate the integrated framework of supply chain risk management for other crops and agricultural enterprises. Future researches may be also conducted to investigate the relationship between risk management, agricultural sustainability and food security. The emerging dimensions of food security such as agricultural virtual water may also be a new avenue for future researches in the context of risk management.

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ANNEXURE

Questionnaire

Cluster member-1, Non-member-2

I. PROFILE OF VEGETABLE GROWERS

1.1 Village_____Block_____District_____State_____

1.2 Gender:_____*(Male-1, Female-2)* 1.3 Age: _____*(Years)*

1.4 Education:_____ *(Illiterate-1, Literate-2, JHS and below-3, Secondary/HS-4, Graduation/PG-5, Professional course/Diploma-6)*

1.5 (a) Agricultural qualification _____(b)Farm training_____(c) Exposure visit_____*(Yes-1, No-2)* 1.6 Social category: _____ *(Gen-1, OBC-2, SC-3, ST-4)*

1.7 (a) Primary occupation _____(b) Secondary occupation _____ *(Farming-1, Service-2, Business-3, Labourer-4, HW-5, Retired-6, Student-7, Unemp.-8, Others-9)*

1.8 Marital status:_____ *(Married-1, Unmarried-2)* 1.9 Family size: (a) Adult male_____(b) Adult female_____(c) Children_____

1.10 Working adult members: (a) Male _____(b) Female_____1.11 Experience in vegetables cultivation :_____*(Years)*

1.12 Yearly: (a) household income ₹_____(b) Income from Agriculture ₹_____(c) Income from vegetables ₹_____

1.13 Land details and farm characteristics: *(1 Acre =.....beegha kachha/pacca)*

Sl.	Land Characteristics -->	Owned	Leased-in	Leased-out	Cultivable land	Vegetable cultivation
a.	Area (beegha)					
b.	Irrigated area (beegha)					

II. IDENTIFICATION & ASSESSMENT OF RISKS ACROSS UPSTREAM VEGETABLE SUPPLY CHAIN & RISK MANAGEMENT STRATEGIES

Risk Category	Sources of Risk	Pre-interventions			Risk Management Strategies	Post clustering		
		S^1	O^2	D^3		S^1	O^2	D^3
a. Input Supply Risks	1. Lack of capital				1. Borrow farm credit 2. Land lease out 3. Contract farming 4. Diversification towards low investment crop 5. Diversification towards livestock/poultry/fisheries 6. Non-farm activity 7. Selling land 8. Do nothing 9.			
	2. Poor quality				1. Purchase from trusted dealers 2. Purchase from govt./coop. society 3. Purchase warrantee/guarantee from dealer/agent 4. Purchase branded inputs from open market 5. Contract arrangements 6. Regular seed replacement 7. Do nothing 8.			
	3. Timely unavailability				1. Prior purchase 2. Liaisoning with input dealer 3. Buy poor quality from open market 4. Sharing with fellow farmers 5. Crop/enterprise diversification 6. Do nothing 7.			
	4. Insufficiency/shortage of inputs (seed/fertilizers)				1. Prior purchase /maintain buffer stock 2. Sharing with fellow farmers 3. Crop/enterprise diversification 4. Buy local brand 5. Do nothing			

					1. Buying when prices are relatively low 2. Collective buying 3. Use of own saved seed 4. Diversification towards low cost			
	5. High cost of inputs				substitute crop/enterprise 5. Contract arrangements 6. Profit sharing with dealer for arranging inputs on credit 7. Do nothing 8.			
	6. Lack of access to financial institutions: bank/MFI etc.				1. Borrow from money lender 2. Borrow from relatives/friend 3. Dispose of non-performing assets 4. Do nothing			
	7. Lack of collateral to borrow institutional credit				1. Borrow from money lender 2. Borrow from relatives/friend 3. Partnering with prime bank customers 4. Switch to low investment enterprise 5. Contract farming 6. Mortgaging 7. Do nothing 8.			
	8. High interest rate for loans				1. Borrow from relatives/friend 2. Borrow through govt. supported schemes (KCC etc.) 3. Borrow through community organizations (SHGs etc.) 4. Do nothing			
b. Production Risks (cultivation & harvest)	1. Weather uncertainty & Climate Change				1. Regular access to weather forecast info. 2. Weather index insurance/crop insurance 3. Water harvesting 4. Adopt new cropping pattern 5. Do nothing			
	2. Crop disease & Termites attack/insects				1. Use of diseases resistance seeds 2. Use of pesticides/insecticides 3. Crop rotation 4. Field sanitation 5. Soil solarization (plastic/other cover to crops) 6. Spray of oil/plant extracts			

				7. Irrigation management/Clean irrigation water 8. Expert/Ag-scientist's advice/ Kisan Call Centre 9. Use of IPM 10. Do nothing			
			3. Insufficient/lack of irrigation	1. Conjunctive water use practices/Integrated use of river, rain, ground etc. 2. Micro-irrigation/sprinkler/water saving devices 3. Cementing drainage 4. Formation of water use groups 5. Water harvesting 6. Change cropping pattern towards water saving crop 7. Crop alone to crop with crop-livestock-other 8. Do nothing			
			4. Lack of access to farm technology	1. Group approaches to buy /access tech. 2. Approach govt. authorities at block & district offices 3. Approach agriculture universities/KVKs etc. 4. Approach to hitech farmers using new technologies 5. Ask through helpline numbers: kisan call centre (KCCt, SMS & phone 6. Visit nearby E-junctions (echaupal/echaba) 7. Use of mass media/ICTs 8. Do nothing			
			5. Lack of technical skills & knowledge of GAP	1. Join farmers field school 2. Attend farm trainings organized by govt., NGOs and private sector 3. Demonstration & farm visits 4. Visit nearby KVK/Ag. University/inst. 5. Watch/listen agricultural programmes on TV/Radio 6. Do nothing			

	6. Shortage of reliable labour/Expensive farm labour				1. Maximum use of family labourer 2. Use of mechanical power technology 3. Land lease-out 4. Grow less labour intensive crops 5. Do nothing			
	7. Illness/Injury/disability/ death				1. Regularly check & repair farm equipment 2. Use farm machines according to the instructions supplied with them 3. Get adequate training & information about handling farm equipment 4. Use protective gear while spraying pesticides 5. Keep first-aid kit at field 6. Buy life insurance policy 7. Do nothing 8.			
	8. Flood				1. Planting water loving crops 2. Reduce run-off 3. Afforestation 4. Grass buffers on agricultural field 5. Conservation tillage 6. Increase carrying capacity of drainage system 7. Strips for soil erosion prevention 8. Do nothing 9.			
	9. Drought				1. Changing crop pattern (drought-resistant crops) 2. Practicing deficit irrigation 3. Mono-cropping 4. Crop insurance 5. Constructing water reservoir 6. Minimizing tillage 7. Selling land 8. Migrating 9. Diversifying non-farm enterprise 10. Do nothing 11.			

	10. Fire				1. Ready with fire protection equipment 2. Collect harvested crops nearby water tank/ pumpset 3. Crop insurance 4. Do nothing 5.			
	11. Hail/ tempest				1. Crop insurance 2. Cover harvested crop 3. Do nothing 4.			
c. Post Harvest Risks	1. Lack/poor packaging				1. Packaging with locally available natural materials (wooden boxes, trays, bamboo baskets & cartons) 2. Packaging with Jute bags and nets 3. Packaging with paper crates 4. Packaging with plastics bags/ crates 5 Attended training for better packaging 6 Sale crop at farm gate without packaging 7 Do nothing 8.			
	2. Poor/lack of labelling				1. Use of own logo/sticker 2. Use govt provided logo/sticker 3 Use of company logo/sticker 4. Write on pack through colour 5 Do nothing 6.			
	3. Lack of branding				1. Mark own designed logo/sticker 2. Mark logo provided by govt. 3. Mark logo indicating specific crop quality 4. Do nothing 5			
	4. Improper product handling				1. Customized packaging 2 Do nothing 3.			

	5. Lack of sorting/grading				1. Do sorting & grading of produce 2. Do nothing 3.		
	6. Lack/poor storage facility/cold chain				1. Sale instant after harvest at farm gate 2. Increase shelf life of produce through preservatives 3. Store at public/private cold storage 4. Marketing contracts 5. Do nothing		
	7. Lack/poor quality control practices				1. Attended training on quality control measures 2. Follow GAP across farm operations 3. Do nothing 4.		
d. Marketing & Price Risks	1. Inaccessibility of market				1. Growing standardized and quality produce 2. Sale in local/periodic markets/ haat 3. Sale at farm gate to local trader 4. Contact local trader /middlemen 5. Group marketing for economies of scale 6. Vertical integration with retailing 7. Supply to restaurants/hotels/hospitals/schools 8. Do nothing 9.		
	2. Difficulties at market place				1. Distress sale due to inadequate storage facilities 2. Sale directly to customers (as hawker) 3. Sale to other marketers 4. Do nothing 5.		
	3. Market price volatility				1 Storage of crop to sale at peak prices 2 Crop insurance 3. Futures /option markets 4 Marketing contracts 5 Do nothing 6		

	4. Lack of market information				1. Use of mobile/phone 2. Use of mass media /ICTs (radio/TV) 3. Use of social network 4. Access from fellow farmers 5. Do nothing 6.			
	5. Low market demand of produce/over production				1. Drying of produce for post season use 2. Do nothing 3.			
	6. Exploitation by middlemen				1. Sale direct to consumers 2. Sale direct to retailer /processor 3. Marketing contract 4. Do nothing 5.			
	7. Lack of discriminatory pricing for quality/graded produce				1. Sale in distant market 2. Direct sale to customers 3. Grow poor quality of produce with little investment 4. Sell at different market/supplier 5. Do nothing 6.			
	8. Lack/poor transportation facility				1. Collective transportation 2. Hire vehicle 3. Purchased own vehicle 4. Do nothing 5.			
	9. Lack/poor bargaining power				1. Collective bargaining 2. Do nothing 3.			

[1&2]S&O-no/least:1-2, ...,moderate:5-6,.....,extreme/very high:9-10. *[3]D-almost certain:1-2,...,moderate:5-6, ...,absolute uncertainty: 9-10.*

Thank you for your time and cooperation!

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